ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY W. H. MAW AND B. ALFRED RAWORTH.

VOL. CVII.—FROM JANUARY TO JUNE, 1919.

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ENGINEERING:

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OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

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24th December, 1918. R 536

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ENGINEERING.

STEAM LEAKAGE IN DUMMIES OF THE LJUNGSTROM TYPE.

In our issue of January 10, 1908, we established a formula for the leakage of steam through a dummy or labyrinth packing of the Parsons type. The formula in question is:

$$w = 68\,\Omega\sqrt{\frac{p_0}{V_0}\cdot\frac{1-\frac{1}{x^2}}{N+\log_e x}} \quad . \quad . \quad . \quad (1)$$

where w denotes the weight of steam passed in pounds per second, Ω the area available for flow at each dummy constriction expressed in square feet, whilst p denotes the absolute initial pressure in pounds per square inch and V_0 the initial specific volume of the steam in cubic feet per pound, N represents the number of rings or constrictions in the dummy and x the ratio of the absolute initial pressure to the absolute final pressure of the steam.

As doubts have recently been thrown on the reliability of this formula, it may be of interest to compare the results given by it with those of an accurate step by step calculation of the discharge through a labyrinth using the precise formulæ given by Professor Callendar. This comparison proves that the formula in question is very reliable even under extreme conditions. In making the calculation we shall assume, as was originally done in establishing the formula, that the coefficient of discharge at each contraction is unity.

The expansion through a constriction is adiabatic, but in each pocket of the labyrinth packing the kinetic energy acquired is destroyed by eddies, so that the steam is completely "reheated" before it expands through the next constriction. Suppose, for example, that at the outset the steam is just saturated and has a temperature of 190 deg. C. Then from Callendar's tables we note that the initial absolute pressure p_0 is 182·08 lb. per square inch and the initial volume V_0 is 2·5339 cub. ft. per pound. Let p_1 be the absolute pressure in the first pocket of the packing.

Then, according to Callendar, we have, if H be the total heat, in pound-Centigrade units, of steam either dry-saturated or superheated, the following relation holds:

$$H = 464 + \frac{pV - 0{\cdot}0123\,p}{2{\cdot}2436}$$

Hence let V_1 be the volume of the steam after its adiabatic expansion* through the first constriction of the dummy. The total heat of the steam at this instant is therefore:

$$H_1 = 464 + \frac{p_1V_1 - 0{\cdot}0123\,p_1}{2{\cdot}2436}$$

* This adiabatic expansion, it is now known, will take place without condensation, and according to the laws applying to superheated steam.

whilst:

$$H_0 = 464 + \frac{p_0V_0 - 0{\cdot}0123\,p_0}{2{\cdot}2436}$$

Hence the adiabatic heat-drop is:

$$H_0 - H_1 = \frac{(p_0V_0 - p_1V_1) - 0.0123\,(p_0 - p_1)}{2{\cdot}2436} \quad . \quad (2)$$

Also, according to Callendar, the following relation holds in adiabatic expansion:

$$p_0(V_0 - b)^{1\cdot3} = p_1(V_1 - b)^{1\cdot3} \quad . \quad . \quad (3)$$

where $b = 0{\cdot}01602$.

Equation (2) may be written as:

$$u = \frac{p_0(V_0 - b) - p_1(V_1 - b) + (p_0 - p_1)(b - 0{\cdot}0123)}{2{\cdot}2436}$$

Hence, if we put

$$x = \frac{p_0}{p_1} \quad \text{and} \quad \rho = \frac{V_1 - b}{V_0 - b}$$

we get

$$u = \frac{p_0(V_0 - b)\left(1 - \frac{\rho}{x}\right) + 0{\cdot}00372\,p_0\left(1 - \frac{1}{x}\right)}{2{\cdot}2436} \quad . \quad (4)$$

From (3) $\rho = x^{\frac{1}{1\cdot3}}$.

In equation (4) the value of u is expressed in foot-pound Centigrade units, and to bring it to foot-pounds it must be multiplied by the constant 1,400.

Let v be the velocity of the steam as it issues from the constriction, then its kinetic energy per pound is $\frac{v^2}{2g}$, and this must be equal to the energy liberated by the adiabatic expansion. Hence:

$$\frac{v^2}{2g} = \frac{1{,}400\left[p_0(V_0 - b)\left(1 - \frac{\rho}{x}\right) + 0{\cdot}00372\,p_0\left(1 - \frac{1}{x}\right)\right]}{2{\cdot}2436}$$

If the discharge takes place through an area of 1 sq. in., the volume passed is $\frac{v}{144}$ cub. ft. per second, but this is also equal to $w\,V_1$ where w is the weight discharged per second and V_1 the volume at the instant of discharge.

Hence:

$$w^2 = 144^2 \cdot w^2V_1^2 = 2g \times$$

$$1{,}400\,\frac{p_0(V_0 - b)\left(1 - \frac{\rho}{x}\right) + 0{\cdot}00372\,p_0\left(1 - \frac{1}{x}\right)}{2{\cdot}2436} \quad (5)$$

Using five-figure logarithms, and taking the pressure in the first pocket as 172·08 lb. per square inch, the initial pressure being 182·08 lb. per square inch, we get from this equation:

$$w = 1{\cdot}2859 \text{ lb. per second.}$$

In the pocket the whole kinetic energy during the efflux through the constriction is destroyed by friction, thus reheating the steam, the total heat therefore when the steam begins to flow through the second constriction into the second pocket is the same as it was *ab initio*. This original value from Callendar's tables was 668·65 lb. Centigrade units. The volume V_1', say, of the steam on reaching the second constriction is then given by Callendar's formula:

$$V_1' = \frac{2{\cdot}2436\,(H - 446)}{p_1} + 0{\cdot}0123.$$

By using five-figure logarithms we get:

$$V_1' = 2{\cdot}6810 \text{ cub. ft. per lb.}$$

We have now to find what the pressure in the second pocket must be, in order to give the same discharge through the second constriction as passed through the first. That is, we have got to solve an equation similar to (5), which may be written as:

$$p_1(V_1 - b)\left(1 - \frac{\rho}{x}\right) + 0{\cdot}00372\,p_1\left(1 - \frac{1}{x}\right) - \frac{2{\cdot}2436 \times 144^2\,w^2\,V_1^2}{2g \times 1400} = 0 \quad . \quad . \quad . \quad (6)$$

We have $\rho = x^{\frac{1}{1\cdot3}}$, whilst $V_2 - b = \rho(V_1 - b)$. Hence all the variables in (6) can be expressed in terms of x and we can solve for x by Newton's rule as given in all text-books on the theory of equations. Proceeding in this way, step by step, the values given in the annexed table were obtained. Five-figure logarithms were used, and all figures were carefully checked at every stage, and finally, by an examination of the differences, which were found to be regular. The discharge as calculated by the exact equation, was 1·2859, so that, as will be seen from the last column of the table, the formula at its worst is not 2 per cent. out and it tends to give too small rather than too large a discharge.

Pocket No.	Absolute Pressure in Pocket p, Lb. per Sq. In.	Specific Volume of Steam in Pocket V', Cub Ft. per Lb.	$\frac{p}{V'}$	Discharge by Formula Through N Pockets Starting from N = 0.
0	182·08	2·5339	71·859	—
1	172·08	2·6806	64·190	1·275
2	161·39	2·8572	56·487	1·274
3	149·90	3·0754	48·742	1·273
4	137·31	3·3565	40·911	1·272
5	123·27	3·7375	32·964	1·270
6	106·99	4·3037	24·861	1·269
Final pressure.	86·69	—	—	—

Strictly speaking, it is an improper use of the formula to calculate by it the discharge from a single constriction, since in deducing the formula it was assumed that the steam was continuously reheated by the conversion back into heat of the kinetic energy acquired on efflux, and no such action occurs when there is but one constriction.

From the figures given in the above table we can find by interpolation the pressures and volumes in

the pockets of a dummy with seven constrictions when the critical pressure ratio is attained at the last constriction.

The critical velocity of discharge occurs when

$$w = 0{\cdot}3155\sqrt{\frac{p}{V}}.$$

Hence in order that the critical stage should be reached at a seventh ring of the dummy, the final state after discharge from constriction No. 6 and reheating should be such that:

$$\frac{p_6}{V_6{}^1} = \left(\frac{w}{0.3155}\right)^2 = 16{\cdot}611$$

Interpolating by the finite difference method we get the following figures as the pressures in successive pockets of a dummy discharging 1·2859 lb. per square inch of clearance area per second, when the critical velocity is attained at the last constriction.

Pocket No.	Pressure in Pocket. Lb. per Sq. In.	$\frac{p}{V1}$
0	173·3	65·08
1	162·7	57·38
2	151·3	49·64
3	138·8	41·82
4	125·0	33·91
5	107·5	25·62
6	89·29	16·61
Final pressure	48·73	—

As stated, the formula is not intended for use when there is only one ring, but if we calculate by it the discharge from the sixth pocket we get, in this instance at any rate, a good result, the formula giving 1·273 lb. per second in place of the true value of 1·286 lb. Taking the two last constrictions the formula gives 1·276, and for the last three constrictions 1·275. For the whole set of seven constrictions it gives 1·271, or within 1 per cent. of the true value.

If we halve the final pressure, then, as the critical discharge has already been attained, the weight passed will remain as before. The formula stands even this test, the discharge calculated for the total range of pressure being now 1·260 lb., which is still in good accord with the exact value.

In dummy calculations it is sometimes assumed that the product of the pressure in one pocket by the drop of pressure through the next constriction is constant. This is only roughly true and becomes very inaccurate as the pressure drop approaches the critical value. This appears very clearly from the foregoing table where the value of this product ranges from about 1,830 to about 3,630. Hence rules derived on this assumption tend to give rather too low discharges.

In deducing formula (1) in 1908 the method used was virtually that of the calculus of finite differences, certain terms being neglected on the assumption that they were small. That this assumption was legitimate is shown by the comparison above made, and a similar procedure will accordingly be used to find a formula applicable to other types of dummy in which the area through the constrictions in place of being constant increases from ring to ring. Dummies of this type are used for the Ljungström steam turbine. The original formula is therefore not applicable as it stands, but a form adapted to the new conditions is easily obtained by the following considerations.

At each constriction of the dummy a certain thermodynamic head q is expended in producing flow past the constriction. The kinetic energy acquired by the steam in its efflux is destroyed by eddies in the pocket into which it is delivered, reheating the steam there, and kinetic energy has accordingly to be generated afresh at each successive constriction. In general q is different at every constriction.

Let U denote the total thermodynamic head, which has been expended in this way when the steam has passed the nth restriction. Then U is the sum of all the values of q up to this stage, or

$$U = \sum_1^n q.$$

In every case U, it will be seen, is to be reckoned after the steam has passed the corresponding restriction. It is convenient to assume that the condition of the steam as it reaches the first constriction is the result of an expansion through an imaginary constriction corresponding to $n = 0$, at which the thermodynamic head expended was q_0.

Then, obviously,

$$\sum_1^n q = \sum_0^n q - q_0,$$

so that,

$$U = \sum_0^n q - q_0.$$

Suppose, as in Fig. 1, we plot down against successive values of n the corresponding values of q. Then the value of $\sum_0^n q$ is obviously equal to the area of the little rectangles shown. For practical purposes this area is equal to that of the curve $OABn + \frac{1}{2}q_0 + \frac{1}{2}q_n$.

But the area of $OABn$ is equal to $\int_0^n q\,dn$, so that:

$$\sum_1^n q = \sum_0^n q - q_0 = \int_0^n q\,dn + \tfrac{1}{2}(q_n - q_0).$$

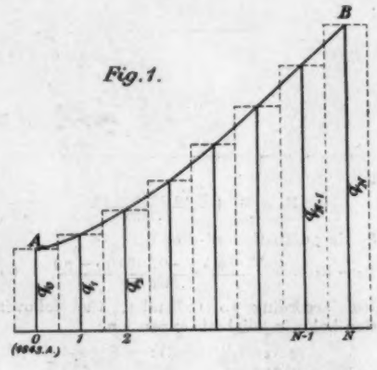


Fig. 1.

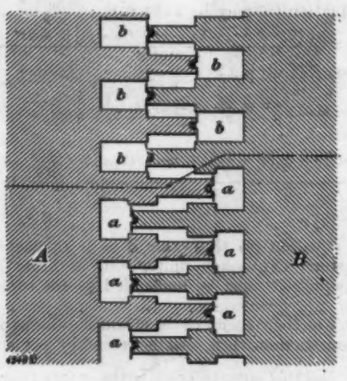


FIG. 2.

Now any function U can always be written in the form:

$$U = U_n - U_0 = \int_0^n \frac{dU}{dn}\,.\,dn.$$

Similarly:

$$q_n - q_0 = \int_0^n \frac{dq}{dn}\,.\,dn.$$

Hence our primary equation,

$$U = \sum_1^n q$$

is reduced to the form:

$$\int_0^n \frac{dU}{dn}dn = \int_0^n q\,dn + \tfrac{1}{2}\int_0^n \frac{dq}{dn}dn.$$

If we differentiate this with respect to n we get:

$$\frac{dU}{dn} = q + \tfrac{1}{2}\frac{dq}{dn}.$$

On re-arrangement this gives:

$$dn = \frac{dU}{q} - \tfrac{1}{2}\frac{dq}{q} \quad . \quad . \quad . \quad (7)$$

Now when steam is wire-drawn the law of expansion is given quite closely by the relation pV = constant. The expansion therefore is hyperbolic, and the value of U for an expansion from the condition when the pressure is p_0 and the volume V_0 to the condition in which the volume is V, is given in British thermal units by the well known formula:

$$U = \frac{144}{778}\cdot p_0 V_0 \log_e \frac{V}{V_0}$$

Whence:

$$dU = \frac{144}{778}\cdot p_0 V_0 \frac{dV}{V}$$

Further, if v be the velocity generated at a constriction, we have:

$$q = \left(\frac{v}{224}\right)^2$$

and if Ω be the area available for flow the volume passing per second will be $v\,\Omega$, which is equal to the weight passing per second multiplied by the specific volume V of the steam.

Hence:

$$q = \frac{w^2 V^2}{224^2\,\Omega^2}$$

Substitution in (7) gives:

$$dn = \frac{9286\,p_0 V_0}{w^2}\cdot\frac{\Omega^2\,dV}{V^3} - \frac{1}{2}\frac{dq}{q}$$

or

$$\frac{dn}{\Omega^2} = \frac{9286}{w^2}\cdot p_0 V_0 \cdot \frac{dV}{V^3} - \frac{1}{2\Omega^2}\cdot\frac{dq}{q} \quad . \quad (8)$$

To find w we must integrate this equation between 0 and N, where N is the total number of rings.

If the diameter of the rings increases in arithmetic progression we may write $\Omega = \Omega_0 + b\,n$, where

$$b = \frac{\Omega_n - \Omega_0}{N}.$$

The left-hand side of equation (8) thus gives us:

$$\int_0^n \frac{dn}{\Omega^2} = -\frac{1}{b}\frac{1}{\Omega}\Big]_{\Omega_0}^{\Omega_n} = \frac{N}{\Omega_0\,\Omega_n}.$$

The first term on the right-hand side is also easily integrated thus:

$$\frac{9286\,p_0 V_0}{w^2}\int_0^n \frac{dV}{V^3} = -\frac{4643\,p_0 V_0}{w^2}\cdot\frac{1}{V^2}\Big]_0^x$$

$$= \frac{4643}{w^2}\cdot\frac{p_0}{V_0}\left(1 - \frac{1}{x^2}\right),$$

where x is equal to

$$\frac{V_n}{V_0} = \frac{p_0}{p_n}.$$

The third term of equation (8) may be written in the following form:

$$\frac{1}{2}\frac{dq}{q\,\Omega^2} = \frac{1}{2}\frac{d\,.\log q}{\Omega^2}.$$

so that:

$$\frac{1}{2}\int_{q_0}^{q_n}\frac{1}{\Omega^2}\frac{dq}{q} = \frac{1}{2}\int_{\log q_0}^{\log q_n}\frac{d\log q}{\Omega^2}$$

But

$$\frac{1}{2}\int_{\log q_0}^{\log q_n}\frac{d\,.\log q}{\Omega^2} = \frac{1}{2}\left(\log_e q_n - \log_e q_0\right)\times \text{mean value of } \frac{1}{\Omega^2}$$

This mean value of $\frac{1}{\Omega^2}$ is of course its mean value when plotted against $\log q$. Since, however, the term in which it is involved merely enters into our final equation as a correction, we shall assume that this mean value is $\frac{1}{\Omega_0\,\Omega_n}$. It must be of this order, and any error involved being only an error in a small correction, will have very little effect on our final result.

Collecting terms, we thus get the following expression for the integral of (8):

$$\frac{N}{\Omega_0\,\Omega_n} = \frac{4643}{w^2}\cdot\frac{p_0}{V_0}\left(1 - \frac{1}{x^2}\right) - \frac{1}{\Omega_0\,\Omega_n}\log_e\left[\frac{q_n}{q_0}\right]^{\frac{1}{2}}$$

Remembering that:

$$q^{\frac{1}{2}} = \frac{w\,V}{224\,\Omega},$$

we get:

$$\log_e\left(\frac{q_n}{q_0}\right)^{\frac{1}{2}} = \log_e\frac{V_n}{V_0}\cdot\frac{\Omega_0}{\Omega_n}$$

which, if we denote $\frac{\Omega_0}{\Omega_n}$ by β, becomes $\log \beta x$.

Hence the final equation for the flow through a dummy of the Ljungström type is:

$$w = 68\sqrt{\Omega_0\,\Omega_n}\cdot\sqrt{\frac{p_0}{V_0}\cdot\frac{1 - \frac{1}{x^2}}{N + \log_e x\beta}} \quad . \quad (9)$$

This reduces to the form for the Parsons type of dummy when Ω is constant.

The result given by equation (9) should be multiplied by a coefficient of discharge, which must be determined experimentally. From some experiments made by Professor Gerald Stoney, F.R.S., it appears that under ordinary conditions this coefficient lies between 0.65 and 0.70.

The formula (9) can also be written in a form which is perhaps more convenient for use, viz.:

$$w = \frac{c}{674}\sqrt{\frac{(d_1 - \delta)\,d_x\left(1 - \frac{1}{x^2}\right)}{N + \log_e \frac{x\,(d_1 - \delta)}{d_x}}} \cdot \frac{p_0}{V_0}.$$

where c denotes the clearance in mils, d_1 the inner diameter of the dummy in inches, δ the pitch between successive rings, and d_x the outer diameter of the dummy. If Professor Stoney's coefficient be adopted, the denominator 674 may be replaced by 1,000.

In the Ljungström turbine the proportionate leakage through the dummy varies with the conditions of working. The arrangement is shown diagrammatically in Fig. 2. Here the part marked A is fixed to the casing of the machine, and the part B to one of the bladed discs. If for any reason the pressure on the turbine disc, tending to thrust it to the left, rises B is pushed to the left. By this movement the clearances at all the inner pockets $a \ldots a$ are increased, whilst the motion does not affect the clearances at the pockets $b \ldots b$. This increase in the clearances at the inner constrictions increases the pressure tending to separate the two discs of the dummy, and the out of balance, which started the motion to the left is thus automatically redressed. Suppose, on the other hand, that the out-of-balance becomes such that B tends to move to the right owing to the pressure inside the dummy being more than is required to balance the pressure tending to separate the bladed discs. Such a motion, it will be seen, will increase the clearances at the pockets $b \ldots b$, whilst not affecting those at $a \ldots a$. The consequence is that the steam that leaks past $a \ldots a$ gets away more freely through the remainder of the dummy and the pressure tending to push B to the right is reduced, the out-of-balance being again automatically redressed. It will thus be seen that only in one special set of conditions are all the dummy constrictions working with full efficiency with an equal clearance in all rings. This condition corresponds to the minimum possible dummy leakage. In actual working the leakage loss will be more since the clearance at some of the rings will be increased in establishing balance. It would be troublesome to calculate out the actual position and consequent clearances of the dummy when it balances the turbine discs under stated working conditions, but a limit can be readily found to the possible maximum leakage. Assume, for example, that the part B moves so far to the left that the full working pressure reaches the first b constriction. This is obviously impossible, but the assumption gives an upper limit to any possible leakage. The real leakage must be less than this limit, but greater than if all the rings were fully effective.

STOKESAY BRIDGE, SHROPSHIRE.

Strengthening a Telford Cast-Iron Bridge by Ferro-Concrete Arch Ribs.

By W. NOBLE TWELVETREES, M.I.Mech.E., M.Soc.Ing.Civ.(France).

Introductory.—In the month of December, 1821, a masonry bridge over the River Onny in the parish of Stokesay,* was washed away by floods, and Thomas Telford, then the county surveyor of Shropshire, built a new bridge in cast-iron on an adjacent site during the course of the succeeding year. After having been in constant service for nearly a century, it was damaged by a traction engine getting out of control as shown in Fig. 1, annexed, and the structure has recently been strengthened by encasing two of the arched ribs in ferro-concrete, thus rendering the bridge fit to carry the heavy traffic of the present day.

The strengthening works were carried out in accordance with the plans and under the superintendence of Major A. T. Davis, M.Inst.C.E., F.S.I., the county surveyor, to whom the writer is indebted for the interesting facts concerning the old structure, as well as for the illustrations accompanying this article. It is believed that Stokesay Bridge is the first Telford structure of the kind that has been strengthened in this manner, but the county surveyor is about to deal in the same way with a similar bridge erected by Telford exactly a hundred years ago on the Shrewsbury and Wenlock main road, half-way between the two towns.

Early History of Telford's Bridge.—In legal documents executed in 1822, it is stated: "The bridge over the River Ony called Stoke Bridge situated in the Parish of Stoke in the said County in the King's Highway there leading from the Town of Shrewsbury in the said County to the Town of Ludlow in the said County has been thrown down by the waters of the said River." This mishap appears to have occurred during the month of December, 1821, as previously mentioned, when

FIG. 1. DAMAGE CAUSED TO BRIDGE BY TRACTION ENGINE.

Mr. Joseph Loxdale, Clerk of the Peace, instructed the county surveyor to report on the matter.

In a report dated December 31, 1821, and signed by "Thos. Stanton, for Thos. Telford," we find the statements: "The situation of this bridge, owing to the position of the weir immediately above it, has always been a precarious one, and it will be necessary that the new bridge should be removed to a different site, either above or below the present one. The precise spot cannot, however, be determined, until an accurate survey and section of the river and roads, for some distance above and below the bridge, has been made, and this shall be done during the present week. In the meantime, I have given directions for preparing materials for a temporary bridge, that not a moment may be lost in constructing one, as the intercourse with the country, by means of carriages, is completely suspended."

Copies of the report were issued by Mr. Loxdale, apparently to the county justices, with a covering letter saying: "Mr. Telford is in the neighbourhood; and as the site of the new bridge is a matter of vast importance, I have directed that he should be applied to, to make a personal survey and report by the sessions. In the meantime I have ordered steps to be taken for the immediate erection of a temporary bridge, in order that the communication with the different towns in the neighbourhood may be restored as soon as possible, and which I hope will meet with your approbation."

The commendable promptitude displayed by the Clerk of the Peace and the assistant surveyor was followed by equally prompt action on the part of the county surveyor himself, for we find that on February 26, 1822, the Clerk of the Peace forwarded for approval to the Hon. R. H. Clive, M.P., and Charles Walker, Esq. (being the committee to whom the matter was referred), Telford's plan and specification for the new bridge and also a draft advertisement for tenders to be inserted in the *Salopian Journal* and *Shrewsbury Chronicle*.

The plan, specification and draft advertisement were approved by the committee on March 9, 1822, and the advertisement was inserted in the papers mentioned, tenders being returnable on April 11, 1822. The tenders accepted were those of Mr. John Straphen, builder, of Shrewsbury, who agreed to execute the "Masonry and Earth Work" for the sum of 1,482*l.*, and the Coalbrookdale Company, whose price for the "Iron Work" was 525*l.* Thus the total cost of the bridge, including a cast-iron arch of 55-ft. span, abutments and other masonry, river and road diversions, a new weir, and incidental works, was only 2,007*l.*—an amount of little more than historical interest at the present time.

Preliminary agreements were signed on April 15, 1822, "in the third year of the reign of our Sovereign Lord George the 4th," and the contract deeds were executed on April 30, 1822.

Figs. 2 to 8, on pages 4 and 5, are reproduced from Telford's original drawings. Fig. 2 is a plan showing the position of the old bridge and that of Telford's "New Bridge." This drawing also shows the new channel cut for the purpose of straightening the tortuous course of the river just above the bridge, and the diversion of the main road to pass over the new bridge. Fig. 3 is a plan and Fig. 4 a section of the weir, Figs. 5 to 8 include an elevation, part plans, and various sections of the structure as completed by Telford.

Telford's specification was very carefully drawn and is expressed in admirably lucid terms. If space permitted, it might well be given in full as an example for some writers of specifications in the present day, but we must be content with a few quotations defining the general scope of the works included in the two contracts mentioned.

"*Bridge Masonry.*—The remains of the former bridge, as marked on the general plan, to be taken down and the materials used in the abutments of the new bridge. The foundations of the abutments and water wings to be sunk to the depth of 10 ft. 4 in. below the top of the existing weir. At this depth platforms, composed of two layers of oak, elm or beech planks and 2 in. in thickness, to be laid crossing each other and firmly pinned or spiked together. These platforms to extend under the whole of the abutments and water wings and for 4 ft. behind the back of each abutment to the width of the wing walls.

"Upon these platforms the foundations of the masonry are to be laid. The whole exterior faces of the abutments to be of as large ashlar as can be obtained from the quarries at Long Lane or Onibury;

* Stokesay was formerly called Stoke and the River Onny was formerly written Ony.

in no case less than from 12 to 15 in. on the beds, which as well as the upright joints are to be truly wrought, also a narrow tooled draught along the top and bottom edges, to set by, and the rest of the face left rough. A proportion of one-sixth of the whole face to be headers of not less than from 2 ft. to 2 ft. 6 in. in length. This springing course to be 3 ft. on the bed and 21 in. in thickness, the remaining thickness of the abutments to be of the rubble stone and bricks of the old bridge, made out and intermixed with large rubble stone from Long Lane or Onibury quarries well bonded with the front work and with each other.

"The wing walls to be founded at the depths shown on the elevations; and to be built of large hammer-faced rubble stone from Long Lane or Onibury quarries. The whole of the abutments and wings to be well coursed, bonded and laid in good lime mortar, and to be grouted full with hot lime and sand on every course. The whole of the masonry as high as 2 ft. above the top of the weir to be laid in good water lime.

"The springing plates and all other ironwork to be fitted and leaded in the masonry. The spaces betwixt the wing walls to be filled with stone rubbish or clean gravel to the level of the roadway. From the face of the abutments, above and below the bridge, there are to be water walls, 20 ft. in length, 4 ft. in thickness at the bottom and to diminish to 2 ft. at the top.

"*Weir.*—The weir to be extended for 66 ft. in length. The foundations to be sunk on the down-stream edge to the same depth as that of the abutments of the bridge, and to be sunk on the back edge by two steps, to a batter on the bed of 3 in. to 1 ft. In these bottoms two rows of beech, elm or oak piles 8 in. or 9 in. square, and properly shod with iron are to be driven, not less than 5 ft. in depth, to which piles, as well as the central row, beech or elm sills, 9 in. square, are to be firmly framed and bolted; or cross tyes of the same material, 9 in. by 6 in., to be firmly framed, dovetailed and otherwise secured to the main sills. Eleven piles to be also driven about the middle of the weir to the same depth as the others, their heads having inch screw pins and nuts let therein to secure a cast-iron plate, 1¼ in. in thickness, down upon the capping or upper course of the masonry. The masonry to be wrought and set in water lime as described for the face of the abutments for the bridge. The inside filling to be of rubble work, closely laid in water lime mortar, and grouted full on every course. An apron of rubble stone to be formed on the upper side of the weir, the interstices closely filled with fine gravel and clay or soil, thrown on the face to form a proper slope.

"*New Channel for River.*—A new course to be cut for the river, average depth 9 ft. 6 in., bottom 40 ft., and the slopes in the proportion of 1½ in. to 1 in. Embankments to be thrown across the present watercourse to confine the water to the new course. These embankments to be not less than 9 ft. wide at the top and to slope on each side at the rate of two horizontal to one perpendicular. A puddle gutter, 3 ft. thick, to be brought up in each from the bottom to the top, properly worked and connected with the remainder of the bank.

"*Road Embankments.*—From the ends of the bridge, embankments are to be formed of the width of 30 ft. at the top and to slope on each side at the rate of 2 ft. horizontal to 1 ft. perpendicular. They are to descend from the centre of the arch at the rate of 1 in 36 until they meet the level of 6 ft. above the top of the present weir. To this level the remaining ground to be embanked until it united with the roads at each end.

"*Road-Metalling.*—Metalling, as shown by the cross-section, to extend over the whole of the new-made road and over the bridge.

Fencing and Hedges.—The whole of the embankments and roads to be fenced on each side with double rows of oak posts and rails. They are to be planted at the proper season with good transplanted three years' old quicksets, not less than nine in each yard.

"*Ironwork of Bridge.*—Upon each abutment to be three springing plates, 21 ft. 3 in. long by 1 ft. broad and 2 in. thick, with joggles 3 in. by 2 in., to receive the ends of the main ribs. Four principal ribs, 1 ft. 6 in. in depth at the centre, and 7 ft. 6 in. at the abutments; these ribs to be 2 in. thick with openings leaving the ribs and bars 4 in. wide. Each rib to be cast in two pieces, to meet in the centre and to be firmly secured together by a grated cross-piece with screw pins or bolts about 10 in. long by 1½ in. square. The foot of each rib to be secured in the socket of the springing plate by wedges and iron cement.

"At about 6 ft. in distance from the abutments and each other, as at A, B and C, in the elevation, there are to be cross-bracers, about 2 in. in diameter, cast hollow to leave a tube 1¼ in. in diameter, with flanches to embrace the surface at the meeting of each rib; through these tubes wrought iron bolts, 1¾ in. diameter, are to be run and firmly screwed at the outside ribs.

"Upon the top of the ribs, covering plates are to be laid, 21 ft. 3 in. long, 3 ft. 6 in. wide and ⅞ in. thick, cast with flanges of the same thickness and 3 in. deep. These plates to be fixed together with screw bolts 4½ in. long and 1 in. square at the distance of 3 ft. betwixt each bolt. Each plate to be cast with 16 joggles, 3 in. wide by 2 in. deep and 1½ in. thick, one-half of the joggles cast dovetailed to be keyed to the principal ribs to secure them in a vertical position and fixed with iron cement; the outer joggles a little larger to show a bracket upon the outside ribs, as shown in the elevation.

"In the railing there are to be principal ballusters 5 ft. 6 in. from each other, 5 ft. long by 2 in. square, cast with feet which are to have toes to pass through and be secured under the covering plate. The side plates, 1 ft. deep and ½ in. thick, to be cast with notches to embrace the principal ballusters and with holes to receive the common ballusters. The common ballusters to be 4 ft. in length and 1½ in. by 1 in.; they are to have a tenon to fit in, and a shouldering to rest upon the flanges of the side plates and a wrought-iron pin cast on the top of each to be riveted through the hand rail. These ballusters to be 9 in. apart with a balluster betwixt each, 2 ft. high, cast in the same form as the larger ones and spear headed. The hand and middle rails to be 3 in. broad and 1 in. thick and firmly fixed to the principal ballusters. The whole to be cast from No. 2 Shropshire iron."

As the reader may judge by the plans and the foregoing extracts from the specification, the bridge and incidental works were well-designed, and all details were thought out in a most thorough manner. The excellence of the masonry and cast-iron construction is demonstrated by the fact that the bridge remained in constant service for a period of ninety-five years without requiring any repairs beyond those covered by the usual maintenance charges.

Fig. 2.

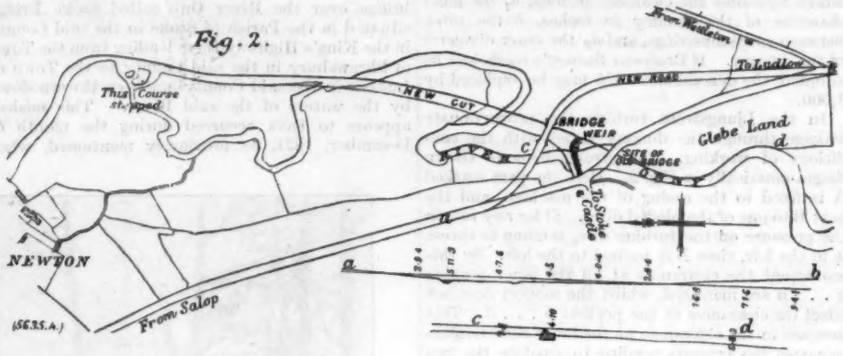


Fig. 3.

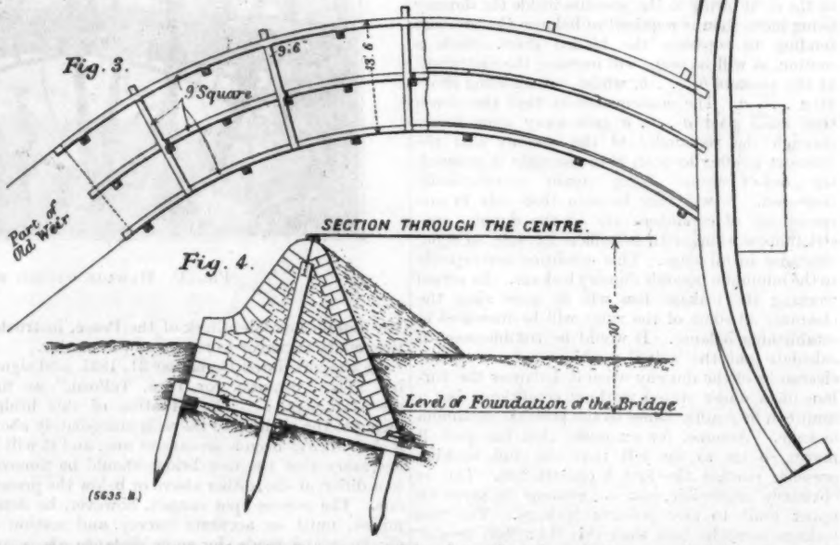


Fig. 4.

Accidental Damage in 1917 and subsequent Examination.—On May 10, 1917, Stokesay Bridge (formerly designated Stoke Bridge) was damaged by a traction engine which ran through the railings and remained in the somewhat precarious position illustrated by Fig. 1. This mishap carried away a good deal of the railing, some of which fell into the river, and caused some damage to the cast-iron kerbs and to the masonry of one abutment. The broken portion of the railing extended for a length of about 56 ft. 6 in., and three of the top rails were cracked beyond the broken portion.

On the recommendation of the county surveyor, a contract was entered into with the Coalbrookdale Company, Limited, the original builders of the cast-iron arch, to make good the damaged palisadings and kerbs, and Mr. T. Pace, of Shrewsbury, was instructed to erect the necessary scaffolding for the

THE STRENGTHENING OF STOKESAY BRIDGE, SHROPSHIRE.

MAJOR A. T. DAVIS, M. INST. C.E., COUNTY SURVEYOR, ENGINEER.

Fig. 5. ELEVATION.

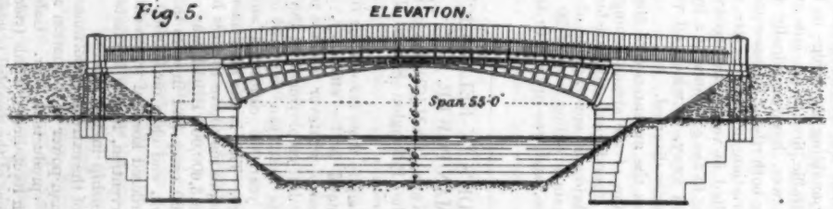


Fig. 9.

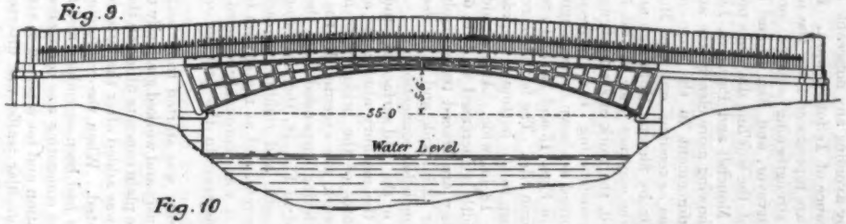


Fig. 6.

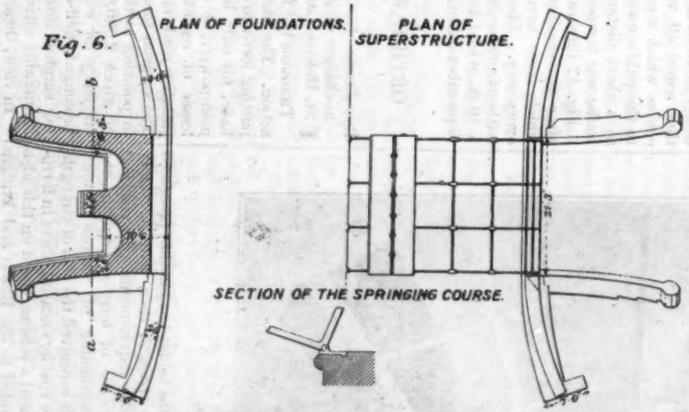


Fig. 10

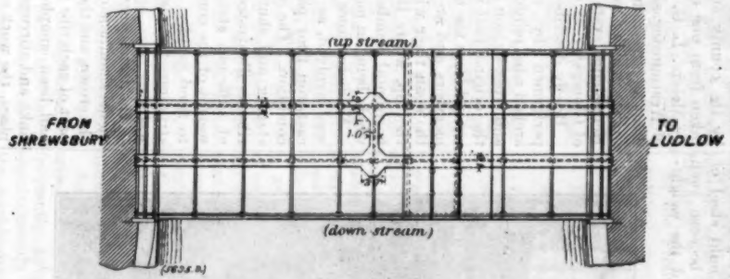


Fig. 7. SEC. THRO' CENTRE OF BRIDGE.

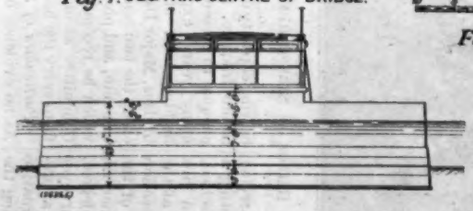


Fig. 8. SECTIONS OF ABUTMENTS THRO' a-b

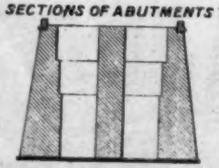


Fig. 11. CENTRE CROSS SECTION.

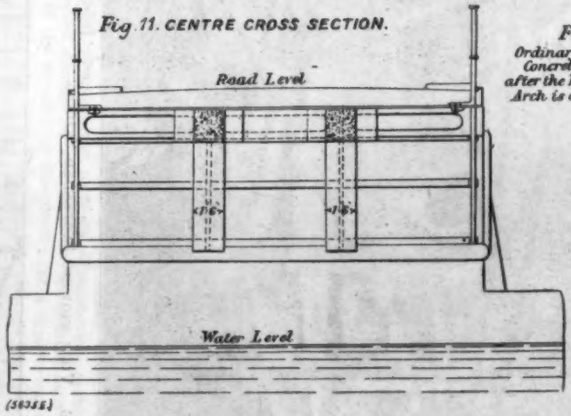


Fig. 12. CROSS SECTION H-H.

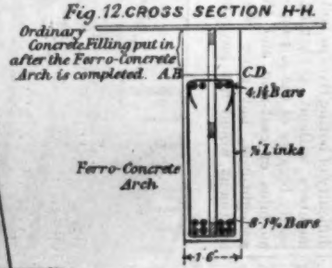


Fig. 13.

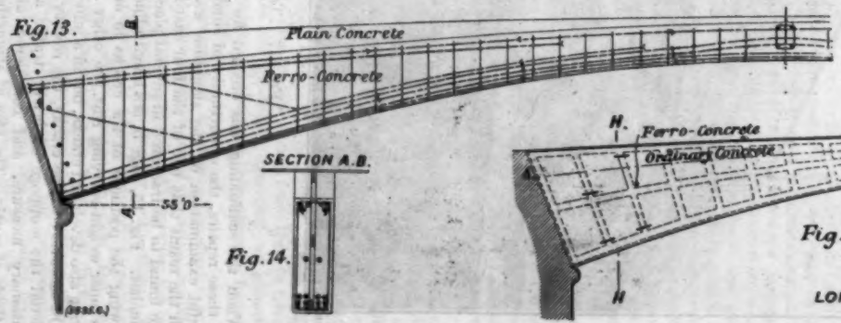
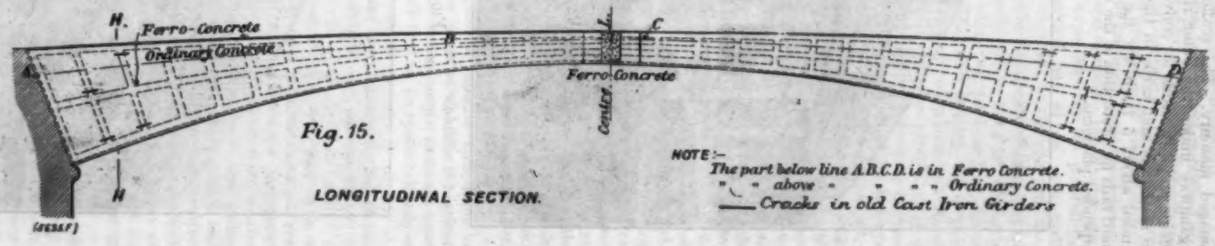


Fig. 14.

Fig. 15.



LONGITUDINAL SECTION.

NOTE:—
The part below line A.B.C.D. is in Ferro Concrete.
" " above " " " " Ordinary Concrete.
___ Cracks in old Cast Iron Girders

repair of the ironwork, as well as to make good the damaged masonry. The scaffolding consisted of a gangway under the outer rib, projecting 3 ft. outside and 3 ft. inside for convenience in screwing the standards and kerbs in their places, and suspended about 5 ft. below the floor plates, with guard rails for protection of the men working on the suspended platform.

FIG. 16. VIEW SHOWING SUSPENDED STAGING.

FIG. 17. THE BRIDGE AS STRENGTHENED.

When the scaffolding was erected for carrying out these repairs, the opportunity of conducting a careful examination of the structure was seized, with the result that two of the four cast-iron ribs were found to be fractured in several places at the haunches. Fig. 15, page 5, is a longitudinal section showing the positions of the cracks in one of the two inner weight-carrying ribs, the other inner rib having also developed cracks, but in a minor degree.

On discovery of the cracks, the county surveyor ordered the stoppage of heavy traffic as a precautionary measure, and considered alternative methods of repair. The idea of strengthening the structure by flitching or fish-plating was considered out of the question, partly in consequence of the difficulty of boring rivet or bolt holes in the cast-iron members without weakening them unduly, and partly because of the difference between the elastic modulus of cast-iron and that of mild steel or wrought-iron, but more especially because such treatment would not have increased the weight-bearing capacity of the bridge beyond that possessed before fracture, its strength then being certainly unequal to present-day requirements. Having had many years' experience of ferro-concrete in the building and strengthening of various county bridges, Major Davis conceived the idea of strengthening the two centre ribs by encasing them in ferro-concrete, and prepared a scheme based on this idea which he recommended to the Roads and Bridges Committee as one calculated to render the bridge fit to carry the heavy traffic of the present day.

Particulars of the Bridge Strengthening Works.—As no evidence of damage was to be found in the two outer ribs, it was proposed to leave these untouched, thereby avoiding any noticeable alteration in the appearance of Telford's work. Figs. 9 to 12 and Fig. 15 are reproduced from the original drawing of the strengthening scheme prepared by the county surveyor, and Fig. 13 and 14 are taken from one of the working drawings prepared by Messrs. L. G. Mouchel and Partners, Limited, of Westminster, showing more clearly the arrangement of the reinforcement in the ferro-concrete work, which was executed on the Mouchel-Hennebique system by Messrs. Hobrough and Co., of Gloucester, at the contract price of 778*l.* 5*s.*

Briefly described, the work of strengthening was performed by constructing two ferro-concrete arched ribs, reinforced as shown in the longitudinal and cross-section in Figs. 13 and 14, and enclosing the original cast-iron ribs. The ferro-concrete ribs extend from the top to the bottom of the cast-iron members and are 18 in. wide. At the middle of the span their width is increased to 3 ft. 6 in. at the top, where they are braced transversely by a horizontal member 12 in. wide and 14 in. deep, the whole being in monolithic connection.

No disturbance of the road surface or handrailing was involved, as the masonry abutments and the cast-iron floor plates of the bridge were in good condition. The work was executed by the aid of staging and shuttering suspended from the outer ribs as illustrated in Fig. 16, the timbering being of sufficient strength and rigidity to carry the weight of the concrete, and as the stream is liable to flood rapidly, it was thoroughly secured to the structure for resistance to the pressure of flood water.

The ferro-concrete was started from both abutments simultaneously and worked gradually towards the crown, and the plain concrete filling on the upper part of each ribs was added after the ferro-concrete had been completed. When the reinforcing bars, links and stirrups had been assembled and fixed in place, the work of concreting was commenced, and during this operation and for a period of six weeks afterwards all vehicular traffic was diverted from the bridge, foot traffic being permitted as usual. The original intention was to strengthen one rib at a time, thereby enabling the bridge to be used for ordinary light traffic, first on one side and then on the other. It was, however, finally thought better to undertake both ribs at the same time, and thus avoid all variation in the concrete work, a course which resulted in very little inconvenience to the public owing to the existence of a bye-road, at a short distance away, to which all vehicular traffic was temporarily diverted.

Fig. 17 illustrates the appearance of the bridge after the completion of the strengthening works, which have been found perfectly satisfactory in every way. The bridge is now capable of bearing without undue strain a rolling load of 30 tons on a 10-ft. wheel base, and was opened to traffic on September 2 last.

ORTHOPÆDICS IN RELATION TO MAN-POWER.

By JAMES R. KERR, Ch.M.(Glasgow), Surgeon-in-charge of the Pilkington Special Hospital, St. Helens (Lancs.).

THROUGH the Empire there is sounding the call to action. The demand is for efficiency, and the putting forth to usage whatever talent a man may have, for only by full employment of the nation's man-power, at its best, can the vast economic losses of recent years be countered and future stability made sure. This is the statesman's view. The surgeon therefore may have the less hesitation in pointing to the 3,600,000 British war casualties of which 2,000,000 cases had injuries threatening efficiency for work, and close on 500,000 required prolonged, well-ordered hospital treatment, involving surgical intervention, in the interests of their serviceable citizenship in the future.

In view, then, of the extreme importance of every addition to the man-power of the nation and to its effectiveness in production, Mr. Galsworthy's apophthegm, with its italicised words (*vide Reveille*, No. 2), "the chance of the disabled is *while the War*

is on," need not be taken too seriously. Beyond and above such consideration, however, there remains an abiding sense of responsibility and gratitude to those men who have done and suffered great things for us. So duty and advantage, approaching hand in hand the problems of injured soldiers, seek out and call into play whatever agencies may improve their condition and outlook. The Royal Warrant of March, 1917, with its arrangements for institutional attention to disabled men, bears testimony to our endeavour. Public approval and admiration have all along been cordially given to the immense work of the Pensions' Ministers. Auxiliary benevolence has promoted their schemes and willing local committees have carried out their instructions.

This, then, is the position. Disabled men in large numbers have been and will be discharged from the Army. For most of these pensioners specially-equipped hospitals, animated with the orthopædic or reconstructive idea, can be, as experience has shown, of great and measurable service. Further, during the periods of hospital treatment, in accordance with the recommendation of the medical authorities appointed for that purpose, full allowances are granted by the State to pensioners and their dependents. But Mr. John Hodge has discerned that it is not sufficient to provide and advertise opportunities. The State must see to their utilisation. The men to whom these hospitals would prove of most consequence cannot estimate in advance the benefits at their disposal. Moreover, the fatalism of the trenches is still with them and they are gently indifferent to many things. Now the Warrant of 1917, for which Mr. G. N. Barnes was responsible, declared by implication, that no man had a right to refuse to be made as well as possible, and attached a penalty to non-acceptance of the provision made for treatment. This bold but statesmanlike decision remains unchallenged in the Warrant of 1918, and it is to be hoped that there will be no falling away from the determination of the Pensions' Ministry, and its widespread executive committees, effectively to hinder the disabled man from throwing away his chance of repair.

It may be suggested at this point that in all industrial centres accidents are happening day by day to men of the industrial army, and it is of interest to know that in Germany, as a direct result of the State's share of responsibility in the matter of compensation in cases of workmen's accidents, there were already considerable provisions for physiotherapy treatment.

In France, the large insurance companies, dealing with workmen's accidents and employer's liability, had interested themselves in methods which tended to lessen the duration of incapacity. So there were years ago institutes for mechano-therapy and massage. Accordingly, by the time the earlier French wounded of this war had got classified as having wounds healed, but with disablement remaining, i.e., as orthopædic cases, the means of treatment accepted by surgeons were actually available.

In August, 1916, the attention of Messrs. Pilkington Brothers, of St. Helens, was directed to this treatment which had been brought again into prominence by the large numbers of returned crippled soldiers who were requiring all that surgical and post-operative treatment could do for them. At that time I was serving France as Chirugien-chef of a base hospital in the Seine region, and so had considerable opportunity of studying what was then being done at various French military centres of physiotherapy, and particularly under Dr. Jean Camus at the Grand Palais in Paris. Consequent on my report to Messrs. Pilkington Brothers, and with the approval of Sir Alfred Keogh and Major-General Sir Robert Jones, a special hospital was established at St. Helens, and soon afterwards it was appointed an orthopædic centre. During the process of construction and equipping we had the benefit of valuable suggestions from the orthopædic institutions which had been established in Britain, and of most helpful encouragement from Major-General Sir Robert Jones, Sir James Barr, hon. consulting physician to the hospital, and other eminent authorities on orthopædic science.

During the greater part of the past two years there has been an ever-increasing demand on the accommodation of the hospital. Its size has had to be quadrupled; its work has been spoken well of by those who know; and its patients have not looked in vain for help from orthopædic methods. Yet it has to be remembered that the source from which these benefits arise is the firm of Messrs. Pilkington Brothers.

At the Pilkington Special Hospital to-day the treatment rooms have the following accommodation:—

For hydro-therapy, 800 men per day can be treated.
For thermo-therapy, 150 men per day can be treated.
For mechano-therapy, 600 men per day can be treated.
For electro and massage, 600 men per day can be treated.
For remedial gymnastics, 400 men per day can be treated.
For curative workshops, 100 men per day can be treated.

The Patients.—We have to do with restoration of the function, that is, of the usefulness of limbs, and we have to make the best of many a bad job. Modern munitions of war, just as modern factory equipment and industrial processes, carry great possibilities of grievous personal damage on occasion. This hospital concerns itself chiefly with disabilities to arms and legs, and a rapid survey of the types of cases admitted is sufficient to convey an idea of the extent and importance of the speciality. More than 60 per cent. of our patients are suffering from damage to one or more of the main nerves. The result is paralysis, complete or partial, of an arm or hand or leg or foot, and loss of feeling in the part which hangs limp, cold and useless. These men must for their own sakes be made fit for wage earning.

Another large class of disability is that which arises from injury to the bony structures. These frequently have added complications, such as a simultaneously received damage to the nerve in the neighbourhood of the wound; or the circumstances of the case may have been such that the limb has been saved, but at a cost. To reduce the patient's handicap and to increase his comfort and usefulness is the objective of this hospital.

A large number of joint cases come under treatment, and they are particularly interesting in so far as their presence marks a definite progress in war surgery along the lines of preservative treatment. That the joint has been saved may be sufficient for certain statistics, but, from the patient's point of view, the criterion of complete success is recovery of its function. It has been our privilege gradually and gently to restore almost full use of many knee joints which would certainly have been lost but for the skill and enterprise of the surgeons who carried out the treatment in the first instance.

Further along this list of troubles we encounter what are well described as "flail" joints—cases where the saving of a limb has been only possible at the expense of an important joint, say an elbow. In some cases it is best to fix the bones by operation at an angle chosen by the patient as the most suitable position for his future work. In several cases special development of muscles, or the transplantation of a muscle to give a suitable leverage for the new conditions, has resulted in a degree of usefulness sufficient to obviate the necessity of an artificial appliance—another alternative.

These three large groups cover a very wide field, but our catalogue of disablements shows almost endless variety. There are numerous disabilities and deformities of hands and feet, all sorts of stiff and useless limbs, and many cases of head wounds with paralysis resulting from injury to the brain, all finding—some more, some less—improvement under the intensive treatment employed.

The resources of modern reconstructive surgery are very great, and it has been the privilege of those of us who before the war had been devoting ourselves to industrial accidents, particularly those involving bones, tendons and nerves, to apply the principles and experiences to the treatment of war injuries. The operative and post-operative methods required for these cases have been improved through the recent experience derived from the enormous number of examples provided by the war, and it is apparent that the workman maimed by industrial accident should have like advantages for treatment.

The Records Room (Fig. 1, on Plate I, published with this issue).—The first step in this work of restoration of function is the examination of the patient and the measurement and recording of his disability in a precise and scientific fashion. These cases present individual problems and demand a broad view associated with special experience in the possibilities of the treatment carried out at an orthopædic centre.

The condition must be accurately measured if the patient and the surgeon are to have knowledge of subsequent progress being real, imagined, or absent. There must be no delusion arising from mere impressions. A disability is examined and simple measurements are made, *e.g.*, the precise range of movement of a stiff elbow is measured in degrees. The wasting in a limb is not judged by the eye, but is measured by the tape. A hand crippled through, for example, shattering of the bones, has its condition gauged by measuring the possible range of movement of each individual articulation. The estimate of returning power in a case of "drop-wrist" is not based on impressions, but on measurements of the angle above the horizontal at which the hand can be voluntarily held. It may be that for months it cannot be elevated at all. Movements of shoulder, knee, ankle, foot, are similarly measured. Certain measuring appliances will be seen in the photograph, on the surgeons' tables and on the top of the filing cabinet of patients' records. Electrical tests are applied and responses of muscles noted. General nutrition is not overlooked, and weight, blood-pressure, teeth, &c., are considered. In the records room the reports from the electro room, the mechano room and the gymnasium are correlated, and the course of treatment is determined, modified, augmented, diminished, as the case may require.

Each patient receives a definite time-table of treatments, giving the hours at which he is required to attend at each of the departments, and each head of a department is advised as to special details of the case requiring attention.

The patient is further scheduled for X-ray examination, splint-fitting or operation as is required.

The Radio Room (see Fig. 2, on Plate I) is a spacious room containing a complete installation in which a powerful transformer-type apparatus is used. Adjoining is a commodious chamber for developing and printing. An ingenious new radio-stereometer gives relief views in two senses, and measurement of depths, with uncommon facility. It is almost superfluous to speak of the part which X-ray examination plays in the localisation of foreign bodies or of the value to the surgeon of its revelations in cases of long-standing injuries to bones and joints.

The Operating Theatre (Fig. 3).—The photograph shows the modern operating theatre with full equipment. The operative work done includes neurolysis, nerve suturing, removal of sequestra, bone transplantation and fixation, re-amputations and plastic operation in addition to the usual emergencies of civil practice.

The Studio (Fig. 7, on page 8).—In the studio an artist makes casts of deformities and provides supporting splints. The casts are valuable aids to the surgeon and serve as records. The splints are moulded from the subjects. In their structure, plaster of Paris is reinforced with fabric and bits of wire, and so the splints are at once strong, light, and perfectly fitting. These splints have their form readily altered from time to time as deformities are gradually overcome or voluntary power returns, and their use is an essential factor in the treatment.

Electro-therapy and Massage.—The electro room supplies invaluable evidence of the actual condition of injured nerve or plexus, and provides the best-known treatment for dealing with them. The essential object is to obtain response in paralysed muscles. No other means supplies the same certainty of maintaining their nutrition during the long interval between injury or suture and physiological repair. The basis of the treatments is interrupted galvanism, and the graduated faradic stimuli advocated by Captain Bristow, to whom we

are indebted for his personal assistance in establishing this department. Ionisation is used to produce the hyperæmia with which it is credited. A large and highly-skilled staff of masseuses is employed, as the diverse phenomena occurring in these war injuries require considerable ingenuity and great patience in their treatment.

Massage is administered in conjunction with the electro room. Movements, passive and active, are prominent in the treatments here, as the futility, even danger, of vigorous massage applied to paralysed muscles, is well recognised. Several electrically-driven vibrators are found useful.

Mechano-therapy (see Fig. 4 on Plate I.)—The mechano room contains over 75 appliances for helping the movements of joints and the development and re-education of muscles. Each appliance is capable of providing a measured estimate of the condition it deals with. Here, for example, the elbow machine has a dial which gives at once the range of bending and straightening.

When power comes back to the affected muscles, adjustable weights are arranged to offer gradually increasing resistance, and the scale on the arms of the balanced pendulums with counterpoises allows of ready recording of the data. Or again, when the paralysis is passing off from, say, a case of "foot-drop," the muscles are encouraged by easy stages against an adjustable resistance and in the regular rhythmic fashion in which they would ordinarily be used, as, *e.g.*, in walking. Likewise, hand and arm commence in the mechano room the re-education of muscles and joints which have been entirely out of action for, it may be, six or twelve or eighteen months. The delicate movements of fingers and wrist, under the guidance of a finely-balanced machine, are helped back to that co-ordinated action which must be the prior stage to any possible usefulness. The importance of these finely graduated active movements cannot be over-estimated, and to that end the entire mechano suite is directed.

I have introduced to England, I believe, the *appareil mural* of Begonin, which is worthy of a place in every general hospital. Its complete adaptability and the provisions for adjustments, modifications and measurements make it of unique utility for war as for civil disabilities. We have 21 examples of this type.

Zander machines, it may be remarked, have been in use in England since 1883, and the modified Zander series is the natural outcome. We have selected those instruments which had proved most useful in France, and we find them of great service here.

In our series of mechano machines none are power-driven, and all are finely poised and capable of delicate and gradual adjustments to suit each individual case. At all times gentleness and gradually increasing range and resistance are fundamental. The day-to-day and week-to-week record of the actual condition as disclosed by each mechano machine and by other measurement is essential to the system. The progress, be it ever so small, if definite and measurable, gives encouragement to the patient.

It is of the greatest importance that all such machines be in charge of someone who, while knowing the objective and the route prescribed towards its attainment, is also known to be alert to any fresh manifestations that may arise. Enthusiasm, patience and perseverance are called for in the mechano room.

Hydro-therapy.—Here, as in the mechano room, great care and quick judgment are required from the staff in the treatment of most of the cases, especially those complicated by total anæsthesia of the part. The equipment is on a large scale, as the illustrations (Fig. 5 on Plate I, and Fig. 9 on page 16) show, and is of several distinct types. There are two "pools," warm and cold, 36 ft. long and 20 ft. broad, lined with artistic white tiles (see Fig. 9, page 16). The warm "pool" contains water at a temperature of from 90 deg. to 100 deg. F., and has a uniform depth of 3 ft. 6 in. This water is kept in turbulent motion by great volumes of compressed air forced into it from orifices in long pipes lying at the sides. Lounge seats along two sides give accommodation for patients sitting immersed to the neck, or resting after exercise in the seething water which provides "hydraulic massage" all the while. Recently, an improvement has been added by passing the compressed air through a powerful ozoniser before it is delivered into the water.

This warm pool is useful in cases of injuries about the shoulder and hip joints by encouraging active efforts by the patient. It has also proved serviceable to a surprising extent in overcoming the spastic conditions resulting from certain brain injuries. The "cold" or swimming pool has a depth of 7 ft. gradually diminishing to 3 ft. 6 in. This pool supplements the effects of the hot pool as progress is made. Helpless or hemiplegic cases are run down into the pools on wheeled chairs or stretchers along the sloping waterways leading into the two pools. Such patients are accompanied in the water by an attendant, himself a discharged soldier who has undergone the treatment.

The hydro room (Fig. 5 on Plate I) contains baths of warm water in a state of agitation and having compressed air forced into it through minute apertures. The percussion of the rushing water, with the air bubbles contained in it, gives a light massage action inducing a definite hyperæmia of the part treated. This becomes reddened, pain is alleviated, and the circulation in numb limbs is encouraged. There is also relaxation of the tissues, which become soft and more amenable to the other treatments. Two of the baths are of the original French *eau courante* model, but we have added the compressed air arrangement to amplify the effect.

Our new design of multiple "waterfall" bath

FIG. 7. THE STUDIO; CASTS AND SPLINTS MOULDED TO THE LIMBS.

FIG. 8. THERMO-THERAPY; HOT DRY AIR TREATMENT.

for arms has been useful in providing for the increasingly large number of patients. These baths can accommodate six arms at a time and the series shown in the photograph illustrates several in action and one at rest. Likewise, multiple baths for legs were required, and they are illustrated. The hot water driven by a centrifugal pump enters these circular baths tangentially and sets up a rapid rotation. In all the baths compressor-driven air adds to the "hydraulic massage" effect.

For disabilities of the feet in particular, the "contrast baths" of Sir Robert Jones are much used. The multiple "waterfall" pattern is found convenient here also. In one series of "waterfalls" the water is at 105 deg. F., and in the other, which is placed alongside, cold water is used. The affected part is placed in the hot water and the cold alternately and in rapid succession. Temperatures up to 110 deg. F. have so far seemed sufficient for the hand and leg baths. A paraffin-wax bath is being used in certain cases.

Thermo-therapy (Fig. 8, on page 8).—Thermo-therapy is represented by a series of 12 felt-lined cabinets. Hot air is applied locally, for example, to hand, elbow, foot, hip. The design overcomes the hygienic objections to the secretion-laden atmosphere in the interior of a radiant heat bath, and at the same time supplies an elevated temperature. We have dry air heated by means of electrical helices forced in a continuous flow through the cabinet, the temperature of the interior of which ranges from 130 deg. to 350 deg. F. as the circumstances of the case indicate.

Remedial Gymnastics (Fig. 10, page 16).—In the gymnasium the very essential treatment of remedial gymnastics is developed under a specially-skilled and experienced teacher. The patients regain here much of their lost confidence in their effectiveness as active members of the community. Apart from such exercises as re-education in walking, after brain or spinal injuries, the gymnasium provides well-ordered assistance in the regaining and improving voluntary use of limbs and joints long kept inactive. The spirit of sport asserts itself and individual endeavour has opportunity of which advantage is cheerfully taken. Much interest is aroused by teams of three men sitting one behind another keeping "stroke" on a rowing machine which they work by two long ropes with attached pairs of handles. The course of instruction is definitely formal and considered, as are also the various games called into service.

Re-education and Personal Work (Figs. 11 and 12, page 16).—As auxiliary to the general treatments of the hospital personal work of various kinds is encouraged. Some men have done excellent volunteer service in the wards, recreation hall, kitchens, lavatories and treatment rooms. In the workshops where joinery, cabinet work, wood and iron turning, smithy work, fret work, boot repairing and some other handicrafts are practised, about 100 of these crippled men, willingly and to good purpose, spend on an average 5 hours per week under expert supervision. As further indication of the spirit which we strive to foster, whereby men are helped back from apathy to self-respect, it may be mentioned that systematic classes in ordinary subjects of education and in elementary science are well attended and enjoyed. In doing work of a definite kind with some measure of success, however slight, the men are being prepared for the workaday world and are realising that not only their happiness in the present, but their welfare in the future, are dependent, in the last resource, on their own efforts and estimates.

Results.—The treatments are useful in overcoming fibrous adhesions, contractures, deformities, with or without nerve lesions, and are apparently of special service also in preparing the limb, its muscles and joints, for the time when physiological union with the central nervous system comes to be established after nerve division and suture.

The method is intensive and persistent, and the effects are cumulative. The results have been beyond my expectations, and justify the title of this article. The nation's man-power at its best is needed. So disablements, whether from war or industrial work, have to be remedied, and one aim of the foregoing statement is to point the way along which restoration of functions may be confidently sought.

INDUSTRIAL NOTES.

On Saturday, December 21, Mr. Churchill, the Minister of Munitions, met representatives of the Employers' and Trade Unions' Advisory Committees, and outlined to them the measures which had been taken by the Ministry of Munitions since the armistice was signed to liquidate the war business of the Ministry and to facilitate the turnover of industry from a war to a peace basis.

When firing ceased, Mr. Churchill stated, we had reached the culminating point in the output of war material of all kinds for the supply of the armies. We had also a whole series of terrifying novelties, some of the most intricate character, and weapons and devices of the most deadly nature, which were in readiness to be used by our troops. Our task was suddenly swallowed up in victory, and the whole further need of these immense efforts made throughout the country by all engaged on munitions was rendered absolutely unnecessary. The task now before the country, Mr. Churchill added, was threefold. The first new task was the liquidation of contracts; the second the rendering of assistance of various kinds to firms to turn over from war industry to peace industry; and the third the disposal of stocks of materials and stores of all kinds in every theatre of war, this applying to every department of State. The stores and other properties might amount to nearly 1,000,000,000*l.* in value; their disposal required detailed and prolonged treatment, and great care at every stage, to hold the balance evenly between the financial interests of the State and the claim of reviving peace industry. It was in the light of these three tasks that Mr. Churchill asked the representatives to consider the demobilisation of the headquarters staff at the Ministry of Munitions.

Mr. Churchill then gave a few examples of demobilisation processes already effected in shell-filling factories, and reviewed the situation of the iron and steel trades of the country, adding that home prices and export prices for steel and iron had been fixed up to May 1, 1919, the gradual removal of the Government subsidies having also been provided for. By these measures, the steel and iron trades had been steadied and had gained confidence. Orders had been booked for export, and so far as home production was concerned, the steel works were already fully occupied. All restrictions on the purchase and manufacture of machine tools were removed almost immediately after the armistice. Similar conditions now applied to iron, steel and non-ferrous metals, to other materials, and also to manufacture in general. The Ministry were doing their utmost to develop alternative industrial production as a stop-gap, pending the complete transition from war to peace industry. The Superintendent Engineers of the Ministry distributed all over the country were advising and assisting firms in their areas; the local Boards of Management were also co-operating in every way. The Ministry were making special efforts to obtain orders from Government Departments, from the Colonies and the Dominions, and also from public bodies with a view to placing those orders to the greatest advantage. Mr. Churchill said, further, that where necessary he was prepared, in connection with Government schemes, and if private orders were not forthcoming, to place covering orders for commodities which would clearly be required in considerable quantities. For instance, he had arranged with the Railway Executive Committee and with the Board of Trade to place orders, if necessary, for 1,000 locomotives and 30,000 or 40,000 wagons in the shops of the country, with special regard to the interests of smoothness of transition from war to peace industry. The Ministry, its Munitions Department, and firms in the country were also devoting themselves to considering the adaptation of useless munitions to articles of commercial use.

The activities of the Ministry of Reconstruction in the formation of Interim Industrial Reconstruction Committees, or temporary Whitley Councils as they are sometimes called, are being resumed, and full Trade Conferences have been arranged as follows:—

(1) For the tubes industry, at the Grand Hotel, Birmingham, on January 8, at 2.30 p.m.

(2) For the paper-making industry, at the Ministry of Reconstruction, on January 9, at 11 a.m.

Mr. E. J. P. Benn, Chief Trade Organiser and Commissioner of the Ministry of Reconstruction, and chairman of the Industrial Reconstruction Council, will preside at both meetings. It is hoped that they will be fully representative of the trades as a whole, both workers' and employers' representatives taking their part.

During the past few weeks, additional Interim Industrial Reconstruction Committees have been formed, in the following trades, among others: Artificial stone; brass and copper; lead mining; lead; zinc and spelter; sugar refining—bringing the number of these committees now at work to 29. They are giving valuable help to the Government on such matters as demobilisation, reinstatement, provision of raw materials, priority and other urgent problems.

We have received a copy of the fourth report of the Special Committee of the London Chamber of Commerce on Trade During and After the War. It reviews the conclusions outlined in the former reports in the light of subsequent changes in the economic outlook, and makes a number of recommendations.

Under the heading "Dumping," the report states that the committee recommended the taking of steps to prevent dumping (and under-valuation) of enemy goods into British markets after the war. This recommendation was endorsed by Lord Balfour of Burleigh's Committee, but, while agreeing in principle with the Canadian system; which appears to find most favour in this country, that committee did not submit a detailed scheme. Such a scheme, however, was outlined in the Chamber Committee's second report, and is intended to apply to manufactured goods in particular, the principle being that the home consumption values in the country of origin, substantiated by consular invoices or certificates of origin, shall be the basis upon which admission is granted. This involves effective machinery being set up by the Customs, whether a comprehensive tariff system be adopted or not, in order to prevent direct or indirect dumping. The report adds that action has been definitely promised by the Coalition Government.

Another interesting point dealt with in the report is the one covering "Key Industries." In this connection it says that the Chamber Committee recommended that H.M. Government be urged to guarantee for a series of years the continuance, by subsidy or otherwise, of new or "key" industries established prior to or since the commencement of the war. This recommendation was also made by the Sub-Committee to the Board of Trade on Commercial Intelligence. Lord Balfour's Committee did not go quite so far, but have suggested in an interim report on essential industries (in which they include as being typical of many, synthetic dyes, spelter, tungsten, magnetos, optical and chemical glass, limit and screw gauges, &c.), that in addition to what has already been done for their encouragement by the Government during the war, special assistance should be given by the State, "with due regard to conditions that may exist after the war." This assistance will, it is suggested, be carried out under a Government body to be called "the Special Industries Board"; failing efficient and adequate output (by private enterprise) it is urged in the report in question that the Government should itself undertake the manufacture of "such articles as may be necessary for national safety."

In regard to these "key" industries, the fourth report referred to, and from which we quote, says: "It will be seen that the principle of the Chamber's recommendation has on the whole received substantial support, and no doubt the intention to set up a Special Industries Board to determine the instances where and the extent to which the support of the State should be given will prevent undue pressure by interested persons to secure preferences to the detriment of such industries as may, from time to time, be capable of development by private enterprise under reasonable competitive conditions. The committee consider, however, that as a general principle, the State manufacture of commodities of any kind is not desirable."

The fourth report from which we have quoted the above few points completes the series issued by the Special Committee. It indicates the changed situation and altered possibilities, as well as new economic problems which have arisen since the issue of the first three reports, with special reference to matters of common interest to the business community as a whole; commercial organisation; industrial organisation; and finance. We hope it will be widely distributed.

A conference was held last week between representatives of the Engineering and the National Employers' Federations, the Shipbuilding Employers' Federation, and the unions affiliated to the Engineering and Shipbuilding Federation, on the introduction of the 47-hour week, when the following arrangements were arrived at, pending further discussion:—

1. The day shift shall terminate at the present hour of stopping in each establishment, unless otherwise agreed between the firm and their men, and

2. Where necessary, in order to make up 47 hours on account of a 12 o'clock Saturday, half an hour extra shall be worked on one evening of the week, unless otherwise arranged between the firm and their men on a 47-hour basis.

3. The rate of men whose normal working week of 58 hours is in excess of the normal district week, *e.g.*, 54, shall be enhanced as if they worked the normal district week.

4. Time rate per hour to be increased for day-shift men according to amount of reduction in hours.

5. Nightshift to be paid on enhanced day rate.

6. Nightshift hours to remain as at present, pending readjustment.

7. Premium bonus earnings shall be calculated on enhanced dayshift rate.

8. No change shall be made in piece work prices or lieu rates.

9. The foregoing are to be considered as temporary arrangements pending further discussion between the federations and the trade unions, without prejudice to either party in dealing with any of the points involved, whether noted therein or not.

The industrial outlook in Germany seems to become more and more gloomy; the strike movement spreads, and the demands of the men grow day by day. One of the concerns hardest hit so far appears to be that of Krupp at Essen. The regular production has come to a standstill and the bulk of the hands have been, or will have to be, discharged. The works are stated to have employed as many as 200,000 men during the war, whilst for the future the Board hold they can only employ some 10,000 to 12,000 men. The stoppage of work costs the firm a great sum every day, and in the meantime the Soldiers' and Workmen's Council have imprisoned a number of the Board as hostages.

The strike of the coal miners in the Essen district is spreading and increasing at an alarming rate, and the men are holding out for extravagant terms, seven hours' shift, 20 marks per day and a gratuity of 1,000 marks to every hand who has worked a minimum of four years underground. In the Deutscher Kaiser and Neumühl mines the men have threatened to destroy the mines and installations if their demands are not complied with.

The men and the officials of the two large electrical firms, Siemens and Halske and Siemens-Schuckert have demanded an increase in wages which will entail an additional outlay of 120,000,000 marks per annum, of which 70,000,000 marks would accrue to the men and 50,000,000 marks to the staff. It was even under consideration for some days to prevent the directors and managers from entering their offices, but wiser counsels prevailed in this respect. Herr von Siemens pointed out to the men that the industry was the backbone of Germany, perhaps the only thing that had not collapsed.

On account of strikes several of the Berlin daily papers have been unable to appear. At the big Wertheim stores the employees have struck for an increase in pay; the management only saw their way to meet them half-way, but even this meant an increase of the annual expenditure amounting to 700,000 marks.

The "atomising" of labour by the formation of "labour councils" is pronounced by a leading liberal paper as a terrible danger to the entire industry. The power of the trade unions now only exists on paper. The Labour Councils—that is the men and the officials in each individual factory—look upon themselves as vested with the supreme power, controlling the situation entirely as they please. Anarchy already prevails in many works. Strikes are started without the slightest excuse, and wages are now in many instances at fancy figures. An unskilled hand, piling up wood or pulling a hand-cart, now draws a wage equal to what a "Geheim Regierungarat" of twenty to thirty years' service receives.

The 47-hours' week is to come into operation in the Sheffield district with the New Year, says *The Sheffield Daily Telegraph*. For many years several of the large employers of labour have contended that the "6 o'clock start" in the morning was unsatisfactory, and at some establishments this has long been abolished. Now it is to disappear entirely in the engineering and allied trades, and 8 o'clock will be the time for commencing the day's work—except on Saturdays, when operations will begin half an hour earlier.

This arrangement is the result of a conference held in Sheffield recently between the Sheffield and District Engineers Employers' Association and representatives of all the local unions who were parties to the joint recommendation of November 19. The conference met to consider questions arising out of the application in this district of the 47-hour working week. An arrangement was arrived at, under the terms of which, as from January 1, the hours of the day shift shall be as follow:—

8 a.m. to 12.30 p.m., 1.30 p.m. to 5.30 p.m., from Monday to Friday inclusive; Saturday, 7.30 a.m. to 12 noon.

Regarding the night shift, it was arranged that this should commence at 5.30 p.m. and finish at 6 a.m., with breaks for meals as at present, this to be a temporary arrangement pending the holding of further conferences to discuss the question of night shift and men working on the shift system.

The decision affects only the various branches of the engineering and allied industries, but no doubt other trades will quickly fall into line, and 1919 will see 8 a.m. as the starting hour generally adopted at all works in Sheffield.

An arrangement to the following effect has been arrived at between Mr. James Cameron, on behalf of the Tyne and Wear engineering, shipbuilding and ship-repairing employers; Mr. John Wile and Mr. T. D. Hebron, on behalf of the joint trade unions:—

"In view of the shortened working week, which commences as from January 1, 1919, it has been arranged between the employers and trade union representatives in conference that the working week be divided as follows, for day shift:—

"Monday to Friday: 7.30 a.m. to 12 o'clock noon; 1 p.m. to 5 p.m.

"Saturday: 7.30 a.m. to 12 noon.

"The foregoing is a temporary arrangement subject to reconsideration during the next three months. Night shift to remain as at present pending further arrangements."

We have received from the Shipbuilding, Engineering and Steel Commercial Staffs Association a circular stating that the said association had been formed to safeguard and further the interests of the members of the commercial staffs in the industries mentioned in the title. The offices of the association are at Church Institute, Hood-street, Newcastle-on-Tyne. The circular states that commercial staffs form an essential section in every industry. By their detailed knowledge of the intricacies of business, they are able to make a unique and indispensable contribution to the life of their industries, a contribution which could not be made by either employers or the representatives of labour. They will have need to safeguard and improve the status of their own class in the modifications of industrial control which will assuredly be made. One of the reasons for the organisation is the question of remuneration which presses with especial severity in these days of increased cost of living. Most firms, the circular adds, have recognised that their commercial staffs need provision to meet this additional burden, just as much as those grades who have been awarded advances from time to time. Some few firms have unhappily dealt less justly with their staffs, and the latter, having no adequate organisation to support their applications for equitable treatment, have had perforce to suffer what amounts in many cases to acute hardship. The circular sums up the objects of the association as follow: (1) To increase the efficiency and status of the commercial staffs. (2) To secure for the commercial staffs proper representation in all schemes of industrial reconstruction.

THE INDUSTRIAL RECONSTRUCTION COUNCIL.—The first lecture of the second series arranged by the Industrial Reconstruction Council will be held in the Saddlers' Hall, Cheapside, E.C. 2, on Wednesday, the 8th inst. The chair will be taken at 4.30 by the Marquess of Crewe, K.G., and a lecture entitled "Industrial Unity" will be delivered by the Right Hon. G. H. Roberts, M.P., Minister of Labour. Applications for tickets should be made to the Secretary, I.R.C., 2 and 4, Tudor-street, E.C. 4.

BRITISH SCIENCE PRODUCTS EXHIBITION AT MANCHESTER.—When we described, in our issues of August 23 and 30, and September 6, 13 and 27, the British Scientific Products Exhibition which the British Science Guild had organised and held at King's College, London, in the four weeks from August 12 to September 7, 1918, we mentioned that it was intended to renew the exhibition in some of the chief industrial centres of the kingdom, if the venture should prove successful. The exhibition was a remarkable success, and on November 1 a meeting presided over by the Lord Mayor of Manchester, decided to bring the Exhibition to Manchester and to house it in the College of Technology, which is certainly an excellent locality, such as the organisers of the original exhibition would gladly have accepted if they had had any choice. The Manchester Exhibition, which aims at helping in particular the Lancashire manufacturer and merchant, was opened on December 27, and will remain open until January 9, 1919. Mr. F. S. Spiers, the organising secretary of the London Exhibition, retains that position. The principal of the College of Technology, Mr. J. C. M. Garnett, is the president of the Executive Committee, which this time has a more local colour, and he expresses his great indebtedness to Mr. J. H. Reynolds, who acted as honorary secretary for a time. Some styles of textiles, and illustrations and printing, appear to be prominent at Manchester. Among firms which we did not mention at King's College are: Messrs. Thomas Armstrong and Brothers (marine clocks) Balstone, Cooke and Co. (velveteens); Bemrose and Sons, of Derby (reproductions of paintings); the Budenberg Gauge Company; the Cambridge Scientific Instrument Company; the Coventry Chain Company; Ellerd Styles, London (water and gastight switches); the Fuller Accumulator Cable and Carbon Works; Hickson and Partners, of Bradford (chemicals); A. Leonard and Co., London (wall callipers); the Precision Optical Company, of New Barnet; the Rembrandt Intaglio Printing Company; the University of Birmingham (high explosives); the University Press, of Oxford; and the Yorkshire Refractories Company.

UNITED KINGDOM SHIPBUILDING PRODUCTION.

It is not possible, says *The Glasgow Herald*, in its comprehensive annual review of trade, to make accurate comparisons between the tonnage production of the United Kingdom in 1918 and that of the previous year, because the returns for the previous year are not complete, but so far as they go the figures indicate a fairly general improvement, corresponding somewhat to that of the Clyde, where the advance was from about 460,000 tons to 556,000 tons. The following table shows the output of the whole of the United Kingdom:—

	Vessels.	Tons.	I.H.P.
Scotland ...	593	633,748	1,969,670
England ...	599	1,029,017	2,192,056
Ireland	53	213,646	187,580
	1,245	1,876,411	4,349,306

The following table shows the production of the leading districts:—

	Vessels.	Tons.	I.H.P.
The Clyde ...	440	555,803	1,900,595
The Tyne ...	111	361,165	935,956
The Wear ...	62	269,628	288,030
The Tees ...	80	227,840	297,675
Ireland	53	213,646	187,580

In output of tonnage Messrs. Harland and Wolff are easily first not only with the aggregate of their Belfast, Glasgow and Greenock yards, but with the Belfast alone. With their Clyde tonnage they head the list for the river, and with their Belfast tonnage they take the same position for the world:—

	Vessels.	Tons.
Harland and Wolff (three yards)	35	219,567
Harland and Wolff (Belfast only)	15	119,445
Swan, Hunter and Wigham Richardson...	29	82,214
Workman, Clark and Co. ...	19	69,370
William Gray and Co. ...	16	62,058
Russell and Co.	10	59,685
William Doxford and Sons ...	11	44,967

For the year first place in marine engineering is taken by the Wallsend Slipway Company, of Wallsend-on-Tyne. If, however, we were to take the whole of the war period into account the Fairfield Shipbuilding and Engineering Company of Glasgow, would almost certainly be an easy first with the 468,410 i.h.p. which they produced in 1916; Messrs. John Brown and Co. second with the 349,400 i.h.p. which they turned out in the same year; the Wallsend Company third with their 346,310 i.h.p. of 1916; Messrs. Cammell, Laird and Co. fourth with the 336,880 i.h.p. which they produced also in 1916; and Clydebank fifth with their 1915 i.h.p. of 319,000. Confining the comparison to 1918, however, the order of the leading firms is as follows:—

	I.H.P.
Wallsend Slipway Company ...	316,290
John Brown and Co.	313,600
The Fairfield Company	291,160
Cammell, Laird and Co.	230,200
J. I. Thornycroft and Co.	211,843
Harland and Wolff	209,600

ELECTRIFICATION OF THE SWISS RAILWAYS.—Switzerland looks to the United States for the means of financing the construction and supplying the raw material for the electrification of its railroads, according to a detailed report made by Vice-Consul Schoenfeld, at Berne, says *The Iron Age*, New York.

EXPORT OF COAL TO DENMARK.—The Controller of Coal Mines announces that the surcharge of 15 kroner per ton levied on all coal, coke-oven coke and patent fuel shipped to Denmark will not be levied on shipments under contracts made with buyers in Denmark after December 31, 1918.

ORDER GOVERNING ACETIC ACID, &c.—The Ministry of Munitions announces that the suspension of the operation of Regulation 30A of the Defence of the Realm Act on acetic acid, grey acetate of lime, and acetone, covers in addition products associated with acetone which have also been restricted under the Acetone Order, including methyl acetone, methyl-ethyl-ketone and acetone oil. Trading in all of the above-mentioned articles abroad, as well as at home, is now entirely free, with the exception of those cases where export licences have still to be obtained from the War Trade Department. No formalities are now necessary in connection with the import of these materials from America.

RADIATION FROM HOT SURFACES.—In a letter recently published in *Nature* Dr. J. A. Harker says that from experiments made at the National Physical Laboratory it appeared that of the total heat which leaves the surface of low-pressure steam radiators maintained at a temperature of 100 deg. about one-half is lost by radiation, the amount being 80 per cent. to 90 per cent., as much as would be radiated from the ideal black body. The remainder of the heat loss takes place by convection and conduction. From bright metallic surfaces the "radiated" loss is only 5 per cent. to 10 per cent. of that of a "black body," but a coat of almost any kind or colour of paint, or even of a thin transparent varnish restores the radiation loss to 80 per cent. to 90 per cent. of the "black body" radiation. Aluminium paints are, however, an exception, since a surface coated with these radiates only half as much as an ideal "black body."

THE VALUE OF OBSERVATION IN WORKS PRACTICE.*

By H. H. ASHDOWN, Newcastle-on-Tyne.

THE title of this paper offers a very wide field for review. It will, however, be appreciated it is impossible to find within the short time permitted to one on an occasion such as this, sufficient opportunity to go very deeply into the subject. It is therefore hoped the points raised may induce careful thought and closer attention in the works to matters which, although they may appear trivial, are of very deep significance. These few opening remarks will perhaps be better appreciated when one realises that profits and losses, dependent on success or failure, are made in the works.

At the outset let me make my object this evening quite clear to you, I am appealing more directly to the practical man; the scientist is well catered for and may do well to devote more time and attention to the many simple but perplexing problems ever present in the works.

Sheffield gained its world-wide repute by its craftsmen, who in the days of the steady building up of its industry were perhaps more observant than those of later decades who may have obtained their reward on a quantitative rather than a qualitative basis. As rivals entered the field and competition became keen and widespread, it realised that quality before quantity was the more important factor, and it was then appreciated in order consistently to repeat quality with the minimum failure the metallurgist was the handmaiden to success. From that time onward the metallurgist became essential to successful works practice, but, unfortunately, speaking generally, even yet the bond of unity so necessary between the practical man and the scientist is not as evident as one could wish.

Nevertheless it must be conceded that scientific research is imperative to the success of industry, but at the same time it should be realised that science cannot teach works practice. It is therefore a great mistake for any of us to assert in the works our scientific knowledge as being the means of success. "Experience keeps a dear school," and until the arts of works practice have been acquired, the application of science is of little value.

The training acquired at a university or technical school, at its best, is only the groundwork on which to build practical experience, and when young men so trained enter the works they would do well to remember they are transferred to the university of commerce for their final training. Although many have been successful, one regrets to say there have been some unfortunate failures, mainly due to over confidence in book learning and to the lack of application of scientific principles.

It must not, therefore, be taken for granted too readily that because one has received a university or research laboratory training, success in the works is assured. Before being given a responsible position in the works a young man should exhibit in addition to discretion, distinct signs of practical application. Success in works practice is not acquired by looking on, but by taking an active part for extended periods, in all operations.

It would appear that there has been a tendency for the pendulum to swing from the practical to the scientific side, but the greatest benefits are to be derived by the happy blending of both the scientific arts and crafts. This has been aptly put in a booklet recently issued by the Institute of Metals, which says: "The practical man may perhaps find that the scientific man is not so formidable nor so unpractical as he may have supposed, while the scientific man may come to recognise that the knowledge of the practical man, though not so formal and well ordered as his own, is none the less very real and deep and valuable."

The chemical training received by students is one of observation and that of chemist, one almost of suspicion, as the latter has to view most substances submitted to him for analysis with considerable doubt. These qualities, if carefully developed and exercised in the works, should be of inestimable value in locating causes of failure and sources of much waste. Indeed, if those in responsible positions in the works would develop within themselves the intuition of a scientific policeman, in place of accepting all operations in progress as being correct, much improvement and progress would result.

During the past four years of war which has closed with an unsurpassed victory to the allied arms, thanks to the skill and unity of the metallurgist and engineer, our industries expanded at a rate far beyond the supply of experienced and scientifically-trained men, and developments were to a large extent dependent on our practical men. The period immediately confronting us, the commercial war, is one of equally great importance, and one which will require all our united energy, indeed the best that science and skill can produce to obtain and maintain our lead in the world's markets. Having, therefore, to accept this position, in order to obtain the best results, together with the maximum output, it will be necessary to continue to lay before our practical men, as plainly as possible, the causes of failure and the easiest roads to success.

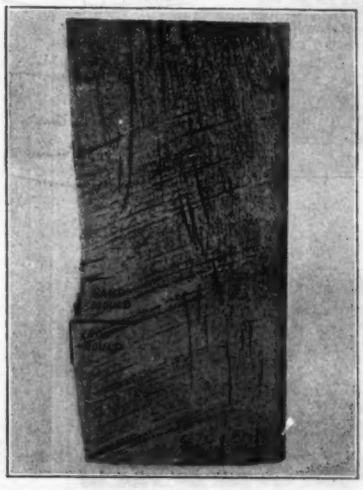


FIG. 1.

FIG. 2.

Now let us turn our attention to some of these points in practice and see what we might observe. Starting with steel-making, although in its manufacture we may use the best raw materials obtainable, that will be no guarantee that the final product will be perfect. Fig. 1 is an example representing a section from a 17-ton ingot, which illustrates at once that the same material might give both good and bad results during forging and subsequent testing, dependent on its rate of casting or solidification in the mould.

Many have learned theoretically, by reading up-to-date books on the subject, how to make good steel, but how many have been successful in practice? In addition to acquiring in every detail the science of the subject it requires years of careful practical study in order to guard against the many pit-falls in the path. Herein then, lies the value of observation.

These remarks apply not only to steel-making, but to the whole of the industrial arts. The forge manager might often save himself a little heart-burning were he more observant. How many examine and note the superficial and general appearance of their ingots before charging them for forging. By noting the condition of the surface one can often guard against failure in forging. It is an easy matter in forging hopelessly to spoil both good, but more particularly delicate materials, and yet it requires comparatively little care to work such materials into perfectly sound and reliable forgings. From these remarks it will be appreciated that much can be done by close intercourse between the steel-maker and the forge manager.

Fig. 2 illustrates the growth of crystals resulting in a weak line sometimes to be observed in the corners of large octagon ingots and emphasises the necessity for care in heating for forging ingots of this nature. Good steel is often hopelessly spoiled for want of care and thought. Many of you will doubtless sometimes have noticed forgings being hammered out after the temperature has fallen almost to a black heat. The effect of such working induces planes of weakness which may be observed in prepared sections of fractured tensile test pieces.

Again, in Fig. 3 is an example often to be met with in hollow forgings, where the end corresponding with the upper portion of the ingot splits badly, due often to two causes:—

1. The concentration into areas of non-metallic enclosures.

2. The aggravation of these areas by cold working.

It will be appreciated that where the drastic working of the material has been sufficient to cause rupture at the ends, the portion farther back, although it may appear sound, will from this cause on transverse testing produce slip fractures. This probably being due to the metal flowing more readily than the enclosures and yet being too cold for these newly-formed faces to weld together again.

Conversely, it is possible to work the material too hot, and there is perhaps more danger in this respect, particularly if, when in this condition, the material is to receive a sudden shock such as by hammering or drop-stamping. You all know that when steel is heated for a long period or to an exceedingly high temperature the crystals develop to a large size and if the material is carelessly struck whilst in this condition it will break off as though it were rotten, exhibiting large cubic crystals.

Now it is not uncommon with hammered forgings, and more particularly with drop-stampings, when under mechanical or fracture test, to note local patches of these ruptured crystals. These defective areas are of course by the forgeman and others attributed to badly made steel, but let me impress upon you they are due in the first place to abnormal heating or prolonged soaking at high temperatures, and secondly to a sudden stress applied to this badly overheated material. It should also be remembered that once this separation of the crystals has resulted, the only cure is the melting pot, as no amount of heat treatment can correct this defect.

Fig. 3.

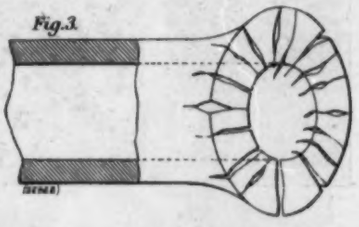
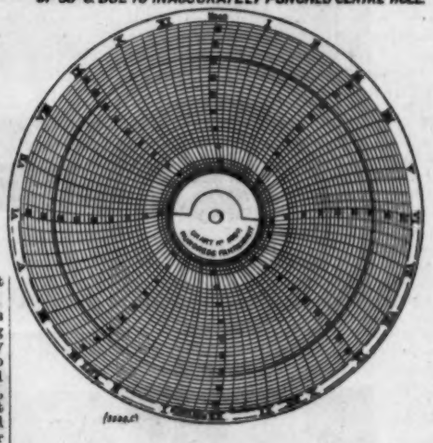


Fig. 4. THE BLACK CIRCLES INDICATE THE RECORDS MADE BY A PEN AT A FIXED READING, & SHOW ERROR OF 50°C. DUE TO INACCURATELY PUNCHED CENTRE HOLE.



When material fractured under these conditions exhibits black cubic crystals it is often termed "burnt" steel. It is true the material has been unduly heated, but if it were allowed to cool somewhat before being worked or, better still, allowed to fall almost to blackness and then reheated, it would make a perfect forging and be equal in every respect to a normally-worked steel. The blackness of the crystals is merely due to oxidisation subsequent to the rupture at a high temperature.

As the successful heat treatment of steel is so dependent on a reliable system of recording heat measurement, a few remarks on this subject might here not be out of place. Pyrometers and recorders to be of any value must be reliable within a reasonable degree of accuracy. Let me give you a few examples which I have met. Complaints were made that at a prescribed temperature a certain steel would not case-harden. On investigation it was found the indicating instrument in use was reading 300 deg. F. too high. Now had those concerned been observant of their furnace conditions it would have been self-evident that the controlling conditions were wrong.

Here is another example, Fig. 4—one of many—with the pin hole of the recording chart punched much eccentric to the graduated scale and such as might give at least 100 deg. F. discrepancy in the readings during a half-revolution of the chart. Thermocouples, sometimes as received from the makers, show at least 50 deg. F. variation between themselves. Other forms of instruments used for heat measurements, when checked against a standard black-body radiation furnace, are also

* Paper read before the Society of Engineers and Metallurgists, Sheffield, November 25, 1918.

at times found to be equally inaccurate. When base metal couples are employed on a series of two or more furnaces which are comparatively close together, misleading records of serious magnitude are apt to be obtained. This is due to the iron tube which forms one of the elements resting on the edge of the hole of the furnace plate where it passes into the furnace. A portion of the weak current generated by the couple is transmitted through the plate which is earthed, to the adjoining furnace plate, and thus to the other couple. Now, if one furnace is hotter than the other, generating a slightly stronger current, there is a tendency for these two couples to balance up and give misleading records.

Here, then, are some of the faults of scientific control, and many users have no alternative but to accept such instruments in good faith, as reliable. In reading through catalogues on pyrometric outfits and control, one is often lead to believe that the manager can sit in his office at a considerable distance from the plant and there control his furnace conditions. There never was anything more misleading. If he is satisfied with a nice regular curve his requirements can always be met by the furnace operators, as they soon become skilled in that art, but what of the condition of the furnace charge and what of the results.

Some eighteen months ago I ventured to suggest that in skilful hands the Siemens water ball pyrometer was an efficient and reliable instrument for certain purposes, but that suggestion appeared to meet with some disapproval, as I think the reason for which it was proposed was misunderstood. I again suggest that for high temperature annealing, normalising and heating for oil quenching where absolute accuracy is not essential the Siemens water ball is a cheap and efficient means of controlling temperatures. One great advantage it has over the thermoelectric control is that it compels the operator to examine his furnace frequently and at a number of points.

As these remarks are apt to give ground for misconception, let me here clearly state that I am an advocate of the best type of scientific heat control that can be applied to works practice. This is absolutely essential where the best results are to be obtained from high duty and special types of steel. Whatever form of pyrometric control may be used, be it of a robust type and of the finest precision, one is still dependent on the conscientious and intelligent observer, as it must always be borne in mind that pyrometers indicate a purely local heat, and it is for the observer to see that uniformity is obtained throughout. This, after all, is the most vital factor.

If you have watched the process and manufacture of forgings, knowing the structural conditions which must result, you will appreciate the more the need for effective heat treatment. Fig. 5 represents one method commonly employed in the manufacture of shafting, and there you will appreciate if two heats are required in order to raise the portion B 2 to a forging heat the portion of the finished shaft enclosed in the chain line must become badly overheated.

It might be thought that if it were possible to work such forgings out at one heat, the risk of overheating would be overcome and normalising might then be unnecessary. Assuming forgings are so made, consider for one moment the conditions which must exist between the two ends. The first end is finished when the material is at almost a full forging heat, whilst the end last finished must be approaching a dull red heat.

In Fig. 6 is illustrated the fractures of tensile test

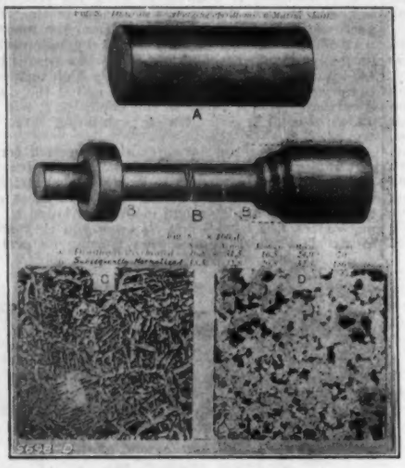


FIG. 5.

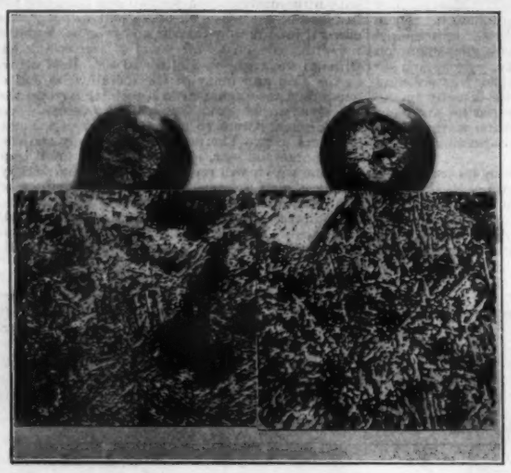
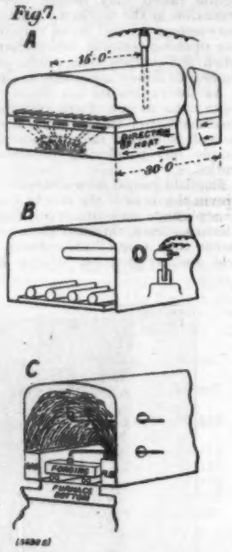


FIG. 6.

Fig 7.



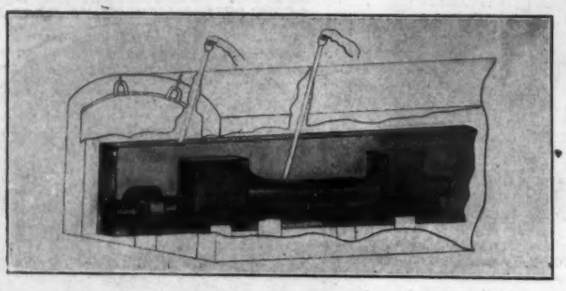


FIG. 8.

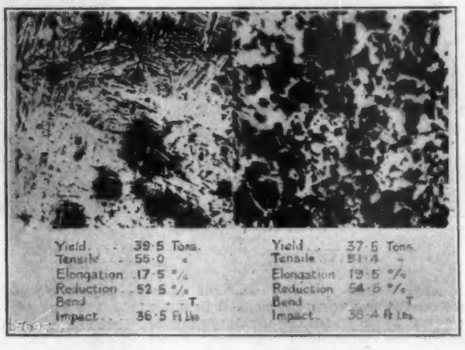


FIG. 11A. FIG. 11B.

FIG. 9.

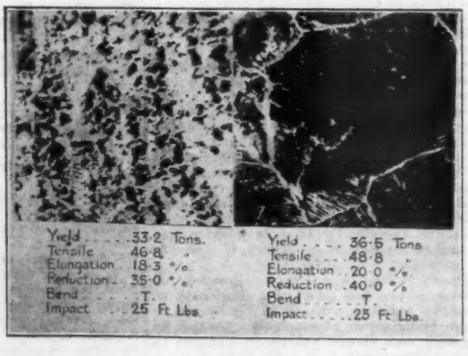


FIG. 12.

pieces taken from the reverse ends of a billet in its finished forged condition, together with their corresponding photomicrographs. These examples are, I think, sufficient to demonstrate the need for a careful subsequent heat treatment.

It might here be of interest to note that the finished stamping temperature of stampings closely corresponds with the temperature of the end of the forging first completed, whilst the finishing heat of the other end of the shaft more closely corresponds with the finishing heat on small hammered forgings, thus the need for more careful heat treatment of stampings.

To ensure success perhaps no operations require closer personal attention than the heat treatment of steel. It is not possible by heat treatment to make badly-made steel good, but it is often possible to bring it into a safe and reliable condition. Again, as I have already shown, it is a most easy matter to spoil, not always hopelessly, the best steel made by leaving it in a condition such that it would not be acceptable to any inspecting engineer.

I have already stated that little reliance can be placed on pyrometric records unless one knows the precise conditions under which they are taken. In Fig. 7 is illustrated types of serious faults occasionally to be met with which are widespread :—

A shows a thermocouple inserted in the centre of the

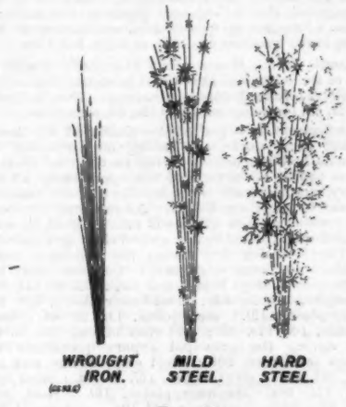


FIG. 10.

furnace, but the condition of the ends of the forgings may be vastly different.

B and C indicate methods sometimes employed, but when examined critically it will be appreciated the temperatures recorded, by no means correspond with that acquired by the work under treatment.

Just consider for one moment the complexity of conditions one might have occurring in a furnace of this description, Fig. 8, perhaps 100 ft. long. Even with half-a-dozen or more stems, badly placed, consistent and concordant results could be shown, and yet the conditions in the furnace might be vastly different. This number of stems is quite sufficient to control such a furnace provided it is in the hands of a skilful and intelligent observer.

Let us for a moment turn our attention to small forgings. When one pyrometer is employed for a single job, even as small as 4 ft. in length, there is no guarantee the forging has acquired uniformly the heat indicated. I have seen certain most important forgings, after oil quenching, with one end dead hard and the other quite soft, resulting from this type of heating, and yet controlled by pyrometers.

Small stampings treated in quantity afford another instance of careless treatment. They are often piled in trays in quantity, four or five deep, and only the outside articles become uniformly heated, and yet these often take the form of vital engine parts. The type and construction of the furnace matters little when conditions such as these are practiced.

Now discrepancies such as I have outlined are to be observed all over the country, and at a time when every pound of steel is of the greatest value to the nation. You all know that when such materials fail to conform to specification they are scrapped and rightly so, as often many lives are dependent upon these parts. If materials become scrapped due to bad treatment alone, a matter which can easily be controlled, those responsible for such are deserving of severe censure.

When presenting a paper on somewhat similar lines some eighteen months ago, I was told that I had hardly done justice to the steel makers in general, or myself in particular, owing to the diffident way in which I had spoken of the efficiency with which scientific principles were applied in works practice. No one appreciates more than myself the immense strides which have been made in the steel works of this country by the infusion of scientific principles into works practice. When, however, we still have occurring every day the shortcomings I have already outlined, we cannot bring ourselves to believe that all is well and that we have reached the high-water mark of success. The more we confront ourselves with our own shortcomings and failures the sooner and nearer we shall approach the stage of perfection. Here, then, also scientific control and all the refinement which has been established by science become fruitless if careful observation is not maintained.

There are a number of practical workshop methods by which one can detect certain conditions and physical properties of material.

The examination of polished strained surfaces (Fig. 9) often indicates the structural condition, but at the same time, although this strained surface may remain perfectly smooth it is not always a guarantee that the structural condition is ideal.

If small pieces, say ¼ in. square, are slightly nicked, gripped in a vice and smartly struck with a hammer, they reveal comparative structural conditions. Here, again, an exceedingly fine grain or fibrous fracture is no definite index to its other mechanical properties, as it is possible to obtain good all-round mechanical results with low impact figures and, *vice versa*, good impact figures with poor mechanical properties. A relative hardness test can be ascertained by equally ready means. Two pieces of unknown material, of either round section, or prepared with an angle, when strongly pressed against each other, by gripping in a vice, will, where in contact, become deformed on the surface, the softer metal exposing the greater depression.

If you have ever watched with more than casual interest the sparks as they leave the grinding wheel when grinding a chisel or a turning tool of high-speed steel, you will have noticed a strong contrast in the type of sparks given off. By this means, then, you have unwittingly perceived a ready method of detecting

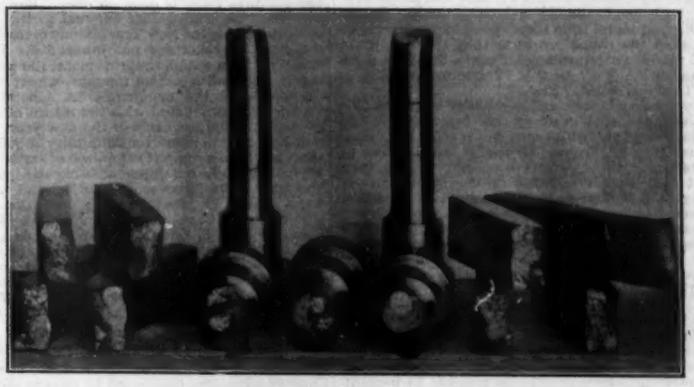


FIG. 13.

FIG. 14.

carbon steel from a high-speed steel (see Fig. 10) By this simple operation it is possible not only to classify the different types of steels, but also to grade plain carbon steels within comparatively close limita. Here, then, assuming all other evidence of identification to be absent, is a ready means for the observant worker or shop manager to detect and rectify a not uncommon trouble in engineering shops, the careless mixing of various types of steel. Although each of these ready means of examining materials physically does not alone impart much reliable information, collectively they put into the hands of the engineer very valuable data.

To this stage I have confined my remarks almost entirely to the practical man. I now propose to invite more closely the attention of the scientific observer. On several occasions I have endeavoured to focus more careful attention and thought on specifications. The conditions brought about during the terrible war now happily at an end have caused our specifications to become a little more elastic, the country in general having gained thereby.

From my own reasoning I am of the opinion that many specifications were framed in the days of wrought iron and mild steel, long before it was appreciated that careful heat treatment conferred such marked improvement on the properties of these materials. During this period under review, when premature failures occurred and the material on analysis revealed a slight increase in the percentage of S, Ph or Cu, quite irrespective of the structural condition, it was assumed the failure was due to the fluctuating presence of these elements. In our conservative way these specifications have been adopted as a standard, limiting our production, enhancing our costs, and thus restricting our markets. Of the three elements I have already mentioned, sulphur and copper have perhaps received the most attention, and on these our minds have been broadened, which has been reflected in our specifications. Phosphorus is still viewed as the most treacherous of these elements; that aspect may be correct, but at what percentage does it commence to exert its adverse effect. In pre-war days anything over 0·03 per cent. was looked upon as detrimental, at present 0·05 is considered its limit of safety.

It has recently been my privilege to examine a cast of nickel steel which by misadventure was found to contain 0·066 per cent. phosphorus. In addition to checking chemically, every forging made from this cast was subjected to transverse, tensile and bend tests, and from each end of each forging nine impact tests were taken.

The average of 32 tensile tests gave :—

Yield.	Tensile.	Elongation.	Reduction.
33·1	46·4	19·5	36·0

and the 32 benders were perfect at 180 deg.

Eighteen impact tests were taken from each forging, the total being 234, and the average figure obtained from this large number was 21·3 ft.-lb., all these tests having been conducted by an independent inspecting body. In view of the whole of these tests being taken transversely, I think this sufficient evidence that up to 0·066 per cent. phosphorus has little detrimental effect.

Another important subject to which I should like to invite your attention is the question of annealing forgings which are to be subsequently oil treated. It is often specified that forgings which are to receive a final quenching treatment must be first annealed at a temperature of not less than 1,550 deg. F. I put it to you : Is this operation necessary ? It is an important question calling for immediate attention at a most opportune time. We all appreciate the shortage of coal throughout the country. If this operation can be dispensed with, in view of the immense amount of material being treated in this fashion, we can save hundreds of thousands of tons of coal, in addition to speeding up production and effecting considerable economy. Provided forgings are properly heated for oil quenching I contend that equally good and perhaps better results can be obtained (including better impact tests), from forgings oil quenched as received from the forge.

In Fig. 11 is an example of what can be consistently obtained not in the research laboratory, but in works practice. These tests were taken from a forging which had been in the hottest part of a forge furnace for 30 hours, the approximate temperature being 1,220 deg. C. It was of nickel-chrome steel, this being chosen

as it is generally assumed this material is more susceptible to overheat.

"A" is the structural condition of the forging as withdrawn from the forge furnace and in this condition it was heated to 1,550 deg. F. and oil quenched and tempered.

"B" represents the other half of this same forging which, after being withdrawn from the forge furnace and allowed to cool, was annealed at 1,600 deg. F. with a batch of large forgings, and after cooling was reheated to 1,550 deg. F., quenched and tempered with "A." In Fig. 12 are other examples taken for comparison from large nickel steel forgings treated in the same fashion.

It is be clearly understood that the suggested suppression of annealing applies only to forgings which are to receive a subsequent quenching and tempering. For forgings which are to be used in the normal or soft condition it is imperative that they should be correctly normalised.

A further matter of interest is an occasional repeating trouble which is met with by some steel makers, and to which I believe no satisfactory solution has been given, that is the silvery white spots sometimes to be observed in broken tensile test pieces or other fractured parts. Although usually silvery white, they are sometimes almost black if they have become discoloured by oxidisation. In Fig. 13 are some examples taken from a forging known to contain these defects; tensile test pieces were prepared both longitudinally and transversely. In the fractured longitudinal tests these defects appear as little slits whilst in the transverse tests they show as white spots. I was recently informed that in Sheffield these defects are called "Z" or "Zee" fractures, whilst in America they are called "Flecs."

A few years ago I gave considerable attention to this matter and found that in every case examined, in the immediate area of the white spot was a small inclusion. It remained then to elucidate the cause and the stage of operations where these defects occurred. It has been suggested that they originated in the ingot, but on examining both hollow and solid forgings these marks on transverse fractures, generally speaking, are almost entirely circular. From this it was evident that these defects could not have been present in the ingot, otherwise the great amount of distortion during forging operations would have left these areas anything but round. The only reasonable conclusion, therefore, that one could deduce was that they were minute clinks which had taken place due to tension in the forging, during cooling, or on subsequent heat treatment, these areas having been weakened due to the presence of the enclosures. By forethought and careful handling of these delicate materials it is quite possible to prevent these defects occurring. It is assumed by some that electrically-made steel is the last word in steel-making.

The strip fracture at the foot of this illustration (Fig. 14) represents the condition of an entire cast of a 5-ton heat. It is a 3 per cent. nickel steel made for a special purpose, and upon which the best care and attention was said to have been given. This is by no means an exception as I am informed, in America this is a serious source of trouble with electrically-made steel.

Drop-stampings sometimes reveal similar defects, but these areas are usually darkened and the defects are not due to the presence of non-metallic enclosures, but are due to the "pull" on the material, whilst in a very tender condition, resulting in the rupture of the crystals.

THE ANSHAN STEEL WORKS.—The new Anshan Steel Works constructed by the South Manchuria Railway, and now nearing completion, are located midway between Chienshan and Lishan. Lishan is but a short distance from the Anshanchan ironnield, which is to supply the necessary ore to the new works. The water supply is obtained in part from the Chienshan River, but chiefly from a subterranean stream at the foot of Shoushan Hill. To begin with, *The London and China Telegraph* reports, two smelting furnaces are to be constructed. These will yield 150,000 tons of pig-iron per annum, which, together with scrap iron and steel, are expected to produce 150,000 tons of steel manufactures. The iron ore wanted by the Anshan Steel Works on its prospective completion is to be supplied by the Chenhsing Mining Company under Sino-Japanese joint management. It is to be mined from the eight mining districts of East and West Anshan, Haiaolingtzu, Takushan, Kuanmenshan, Yingtaoyuan, and Wangchiaputzu. The ores consist of magnetite and hematite, both of excellent quality. Each mining district has an abundance of iron ore. In particular at Yingtaoyuan, East and West Anshan, and Takushan outcrops of ore can be seen almost everywhere. The hills there may be called masses of iron ore. Consequently, the mining work may be carried on with great ease. Not a level need be excavated. The hills may be subjected to excavation from the very top, like open casts. Mining preparations have been made at Yingtaoyuan and West Anshan. Housing accommodation for single officials and employees are to be built by the South Manchurian Railway Company. Quarters having a capacity of 250 are now completed or are nearing completion. With the employees' houses in the centre, a town site for the works colony has been selected on both sides of the railway track at the new Anshan station. In the new city plan, the residential quarters for Japanese and Chinese are separated from each other and a business district is set apart in the Japanese quarter. Moreover, the workmen and lower class and higher class employees are to have their own residences grouped together. In addition, the construction of a primary school, a market place, a hospital, and a fire brigade station is included in the building programme for the current fiscal year.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—For the first time for four years a substantial holiday is being taken in the iron and steel trade of the district. Beginning in many cases the Saturday before Christmas arrangements were made for work generally to be resumed in some instances on Wednesday, the 1st inst., and in others on the Monday following. The rolling mills, tilts and forges shut down for ten days. The experience immediately preceding the holiday fully justified the optimistic views hitherto taken of a quick revival in business, and ample employment for labour. In view, however, of the withdrawal from the works of large numbers of those who took munition jobs as an alternative to military service, the industrial position is somewhat serious, and until there is a drastic change in demobilisation, trade will suffer from a shortage of men. Employment is plentiful. All the local rail plants are working at full pressure and makers are literally snowed under with inquiries for axles, tyres, springs and other railway material. While there is less doing in some of the higher qualities of crucible steel, inquiries for a commoner grade of material are plentiful.

South Yorkshire Coal Trade.—The markets are firm, with a brisk inquiry for all classes of fuel, but owing to the holidays there is little on offer. Supplies from the pits have been altogether unequal to the demand, and as in most cases the New Year holiday occasioned a further stoppage, the shortage was intensified. In house coal there has been a slight improvement, the works' holidays having released a certain tonnage, which has come into the hands of the merchants. A general recovery is confidently anticipated with the return of large batches of men demobilised early in the new year. Steams are still in strong demand for Admiralty requirements, and there has been a complete stoppage of exports to neutrals, all coal available for shipment being consigned to France and Italy. Slacks are more plentiful, but eagerly sought after. Coke is moving freely at maximum prices. Quotations:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

CHADWICK PUBLIC LECTURES.—A course of three Chadwick lectures, illustrated by lantern slides, are to be delivered by Mr. Arthur H. Barker, B.A., B.Sc., on "Fuel Economy and Health," in the lecture room of the Royal Society of Arts, John-street, Adelphi, W.C. 2, on Monday, the 6th, 13th and 20th inst. The subjects are to be: "The Heat Requirements of a Human Being"; "The Heat Requirements of a House" and "Heat Economics." Further particulars may be obtained of the Secretary, at the offices of the Chadwick Trust, 40 (6th), Queen Anne's Chambers, S.W. 1.

THE COOLING AND EVAPORATION POWERS OF THE ATMOSPHERE.—At a meeting of the Royal Society, held on December 12, 1918, a paper was read by Messrs. Leonard Hill, F.R.S., and Hargood Ash, on the "Cooling and Evaporative Powers of the Atmosphere, as Determined by the Kata-thermometer." The authors stated that a further investigation has been made of cooling power of air at known temperature and velocity of movement in the large wind tunnels at the East London College, with the aid of Mr. N. A. V. Piercey, the lecturer on Aeronautical Engineering, timing the rate of cooling of the kata-thermometer, a large-bulbed spirit thermometer graduated between 100° and 95° F., and the factor of which was determined whereby the cooling power on a surface at body temperature is expressed in millicalories per sq. cm. per sec. The formula was deduced $H = (0{\cdot}27 + 0{\cdot}49\sqrt{v})\theta$ where θ = the difference between the temperature of the air and 36·5° C. Using this formula they found the velocity of the wind determined by the kata-thermometer at Kew Observatory agreed closely with the velocity determined by the Cup and Dines anemometers. Using this formula to determine velocity, the cooling of the wet katathermometer was reinvestigated in a tube 3 in. in diameter, through which air was drawn from a chamber, the temperature and humidity of which could be varied. The formula was deduced $E\,(F - f)^{4/3} = 0{\cdot}085 \times 0{\cdot}102\ V^{0{\cdot}5}$ for expressing the evaporative power, the full formula for the cooling of the wet kata-thermometer then being:

$$H = (0{\cdot}27 + 0{\cdot}49\sqrt{v})\,\theta + (0{\cdot}085 + 0{\cdot}102\ V^{0{\cdot}5})\,(F - f)^{4/3}.$$

The effect on evaporative power of varying the temperature of the evaporating surface was determined, and the use of the kata-thermometer as a measure of evaporative power of drying processes pointed out. The effect of barometric pressure on cooling power was worked out in a chamber in which the atmospheric pressure was varied from + 15 lbs. to 340 mm. Hg. The results were found to agree with the formula theoretically deduced

$$H_1 = \frac{H_0}{2}\left(1 + \sqrt{\frac{p_1}{p_0}}\right)$$

where H_1 = cooling power at pressure p_1, and H_0 = cooling power at atmospheric pressure p_0. The formula expresses influence of barometric pressure on convection cooling power. At ordinary temperatures cooling power exerted on dry kata-thermometer is half due to radiation, half to convection.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—With holiday still general, business is practically at a standstill. In many cases local deliveries of pig-iron have been suspended over the Christmas period, and with this week's New Year holiday in Scotland little or no pig-iron is going to customers North of the Tweed. Thus with home demand cut off for the present pig-iron producers would appear to have opportunity of accumulating some stock, but this is not so, as any available iron is eagerly taken up for export. For Allied countries, other than France and Italy, a few export licences are reported obtainable, but permits for shipment to neutrals are still withheld. Inquiries on neutral account have been very heavy and pressing, and hope is expressed that in the near future some official action will be taken with a view to resumption of this important branch of trade. Export business with Italy can now be put through private traders, but such business is checked by difficulty of arranging credits. Trouble has arisen by the disinclination of pig-iron producers to allow merchants the official 1¼ per cent. commission on export transactions, and it is understood that the authorities have been asked to put the matter on a satisfactory basis. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 95*s.*, and for export No. 3 and the lower qualities are 145*s.* and No. 1 is 150*s.*

Hematite Iron.—Home needs practically absorb the whole of the output of East Coast hematite iron, so that little or no foreign business is passing. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use and 172*s.* 6*d.* for export.

Manufactured Iron and Steel.—Nearly all the finished iron and steel works are having an unusually long Christmas holiday, largely owing to the coal shortage, and are taking advantage of the opportunity afforded to carry out necessary work involved in the transition from war to peace conditions. An immense number of much-overdue private orders will provide work for a long time, and thus the outlook is quite bright and encouraging. The following are among the principal market quotations to home customers:—Common iron bars, 14*l.* 10*s.*; steel ship, bridge and tank plates, 11*l.* 10*s.*; steel angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; chequer plates, 13*l.*; steel joists, 11*l.* 2*s.* 6*d.*; heavy steel rails, 10*l.* 17*s.* 6*d.*; and steel billets, 10*l.* 7*s.* 6*d.*; whilst among the principal export quotations are: Common iron bars, 20*l.*; steel ship, bridge and tank plates, 16*l.* 10*s.*; steel angles, 16*l.* 2*s.* 6*d.*; steel boiler plates, 17*l.* 10*s.*; chequer plates, 18*l.*; steel joists, 16*l.* 2*s.* 6*d.*; heavy steel rails, 15*l.* 10*s.*; and steel billets, 13*l.* 10*s.* to 15*l.*

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough for the last month of the year totalled 42,689 tons, of which 28,513 tons were pig-iron, 251 tons manufactured iron, and 13,925 tons steel. For the previous month the loadings reached 38,832 tons, of which 31,070 tons were pig-iron, 360 tons manufactured iron and 7,402 tons steel.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has issued a new set (No. 71) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

THE LATE MR. STEPHEN PRESCOTT WHITE D'ALTE SELLON.—We regret to have to record the death, which occurred suddenly on December 22, of Mr. S. P. W. D'Alte Sellon. Mr. Sellon was the son of the late Rev. William Edward Sellon, Rector of Kentchurch, Hereford, and was educated at Uppingham and King's College. He was a well-known tramway engineer, and for many years he acted as consulting engineer in London to several corporations and tramway companies. He was a member of the Institution of Civil Engineers since 1903; he contributed to the proceedings of the Institution and was awarded the Telford premium.

BLAST FURNACE POTASH.—One of the remarkable metallurgical and economic results of the war, says *The Iron Age*, New York, has been the production of potash salts as a by-product from sources hitherto passed by. The iron blast furnace is furnishing a large part of the new supply. That blast-furnace dust contains potash salts, which are recoverable in commercial quantities, was discovered by an American blast-furnace superintendent, W. J. Wysor. In Great Britain the results obtained have been striking. The ores there used seem to be especially adaptable to the recovery of potash, and it is an interesting fact that the addition of salt to the charge has increased the output. At one plant large quantities are produced each week, and it is stated that the country's output can easily be increased to 50,000 tons a year, or enough to satisfy all demands. An American investigator, Linn Bradley, has recently called attention to the fact that Southern iron ores, particularly those of Alabama, can be made a prolific source of potash. At a recent convention of the National Fertilizer Association in New York, it was shown that this year's output of potash would largely exceed the 1917 output of 32,000 tons, and that it would be possible, by mobilizing all the raw material of blast furnaces and cement mills to reach an annual production of 500,000 tons. This is nearly twice as much as formerly came from Germany; the American imports just preceding the war were 283,000 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—With the closing down of the engineering works and shipbuilding yards in and around Glasgow on Saturday, instead of a couple of days later, a new era may be said to have come into being as, when work is resumed after the New Year holidays on Monday next, January 6, the shorter working day will come into operation. How this will affect the steel trade remains to be seen, for the numbers of orders at present on hand will call for much activity for some considerable time. In the home markets there is much pressure for delivery so that right down to shutting-up time on Saturday working conditions were of the busiest possible description. The steel required for purely mercantile purposes is now greatly in demand, and in consequence opportunity will be taken during the holiday week to make such alterations in plant, &c., as the transition from war to peace work renders necessary. In addition to this, the customary repairs to and overhauling of machinery will be put through, so that a good start may be made when the men resume work. The scarcity of fuel still constitutes a serious difficulty to production in not a few instances, although it is hoped that with the return of so many miners to their usual occupation this difficulty may speedily be overcome. No delay can be brooked in this direction, as inquiries from overseas customers are rolling in, and while it is impossible at the moment to consider these, they are a source of revenue which steel makers have no desire to drop now that they are free of war work.

Malleable Iron Trade.—At the close of the year the malleable iron trade remained in the flourishing condition which has characterised it during the years of war, makers having well-filled order books and every prospect of much prosperity ahead. Now that Government is out of the market for the class of material so urgently required for war purposes malleable iron makers are endeavouring to overtake the arrears of work which have steadily accumulated and with new demands pouring in as well they are likely to have their hands full for a long time to come. Even at the amended rate of 18*l.* 10*s.* per ton net, f.o.b., "Crown" bars are being much sought after by overseas consumers. Just how long this "record" figure will hold is a question which no one is prepared to answer in the meantime, but with additional labour, a better supply of fuel and a more extensive system of transport there is every likelihood of a rapid fall in price.

Scotch Pig-Iron.—The demand for pig-iron of all grades continues to be one of the features of the trade—indeed, so great are the requirements that even with a most extensive production smelters find difficulty in supplying the orders which flow in. Supply and demand, therefore, keep pace with each other, and in consequence it is neither possible for any stock to be accumulated, nor for export of any dimensions to be run off. There is some uncertainty as to how things will move in the New Year.

PERSONAL.—Mr. L. C. Harvey, the author of the report on the Pulverised Coal Systems of America, recently made to the Fuel Research Department, is now taking up consulting practice at 25, Victoria-street, Westminster.

THE GENERAL DEPRESSION IN GERMANY.—The most striking feature in German commercial circles is a universal inclination to cancel orders, although such action is not even legally defensible. In the meantime, the financial barometer continues to fall, both as regards shares and the German exchange, which is now lower than ever, a circumstance which very seriously handicaps the supply of raw materials from abroad. There have been very heavy falls in the quoted values of very many industrial shares.

THE GERMAN ZINC UNION.—The former official distribution of the orders has now come to an end, and as soon as circumstances will allow, a meeting of the interested concerns will be arranged. The altered state of affairs also means that prices, for the future, will be fixed by the Zinc Union. With the cessation of the maximum price, it is understood that the price for indirect military orders, 130 marks per 100 kilograms, will be fixed as the peace price; before the war it was 40–45 marks per 100 kilograms. It is admitted that the time for forming an international zinc syndicate has not come yet.

A NEW STOPCOCK.—The novel form of stopcock, described by Harry L. Fisher, of Columbia University, New York, in the *Journal of Industrial and Engineering Chemistry* of December, 1918, is designed for securing that drops of liquid will fall from one vessel into another independent of any pressure differences between the two vessels. When the lower vessel is, *e.g.*, a generator of carbon dioxide containing a carbonate, and the upper vessel contains acid, the pressure in the lower vessel may be above or below atmospheric, and the drop-feed of acid through the stopcock in the connecting tube between the two vessels may be interrupted by the pressure variations. To obviate this interruption, an outside tube may be used to connect the two vessels. The stopcock proposed is a composite tube rather than a mere valve, and the key is provided with an annular groove which always maintains a by-pass connection between the two vessels, no matter which position the key occupies. The connecting tube itself is partly double, the one tube opening above the liquid level, the other below it. The device might be utilised for lubrication.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—During the past week or so holiday influences have dominated the South Wales coal markets. The Christmas holidays naturally interfered with production, but due credit must be given to the miners that they responded very well to the appeal made to them by the joint secretaries of the Coal Board to resume work promptly on Friday instead of prolonging the holidays to three or four days as was customary in pre-war days. The result was that the outputs last Saturday approximated the normal production on the last day of the week, and reports from the collieries this week again are quite favourable. The shortage of coal, however, still continues acute. There are pressing inquiries, but it is found impossible to release any coal for private shipment. The bulk of the export is on official account and commitments to allied destinations over the week are so heavy that there is little prospect of any coal being released for private trading purposes for some time. The pitwood position has slightly improved this week, but the shortage continues, and very little wood is being brought over from the Bay. So far, however, collieries have not been seriously affected. There is an abundance of tonnage in dock, but shipments are restricted both by the comparative shortage in the supply of coal and by the dearth of efficient coal-shipping facilities.

Newport.—The Alexandra Docks have again been congested with tonnage, and although tipping is being proceeded with as actively as possible, the shortage in the supplies of coal is such that a large number of vessels are awaiting their turn for berths. Outputs of Monmouthshire coals have unquestionably improved, but the inland market is absorbing the greater part, and pressure is being brought to bear to increase the proportion set apart for export. The pitwood position is causing some measure of anxiety, and stocks are now stated to be lower than they have been for a considerable time past.

Miners' Six-Hour Day Demand.—When the Executive Council of the South Wales Miners' Federation met at Cardiff on Wednesday, a resolution was adopted formally committing the organisation to the advocacy of a 6-hour day for miners. The Council, however, abstained from dealing with sequential problems, and contented themselves with a decision to appeal to the Miners' Federation of Great Britain to take the matter in hand without delay. The proposal was supported chiefly from the point of view that there would have to be a curtailment of the hours of labour in order to provide employment for the returned soldiers. No doubt difficulties will be experienced in this connection. The men who flocked to the Colours, particularly under the voluntary *regime*, are fully justified in their claims to reinstatement, both by reason of the services which they have rendered to their country on the battlefield and by the definite promise of employers to keep their places open to them on their return. To all appearances, however, new circumstances have made it a practical impossibility at the moment for the industry to retain those workmen who entered the pits after the war and at the same time absorb all the labour that is now being demobilised, and the situation created is one which will have to be dealt with promptly and energetically by the co-operative efforts of owners and workmen's leaders. During the period of the war facilities for transport of coal from pit to port have deteriorated considerably, while collieries are not in a position to employ at once as many men as they did before the war owing to the restraints which have been placed on developments and extensions since 1914. These altered circumstances must, therefore, be taken into account, but it is obviously fallacious to suggest that the curtailment of the hours, *per se*, can have any remedial effect. If the South Wales miners' leaders and their constituents were prepared to agree to the adoption of a double shift as a corollary, then their proposal might be more likely to prove arguable, if not acceptable. So far, however, they have shown themselves strongly antagonistic to such a proposition, and the position at present is certainly one which causes a great deal of concern to all who are interested in the industry.

General Coalfield Issues.—Among the questions which have been referred by South Wales to the Miners Federation of Great Britain is that consideration be given at an early date to the arrangements which are to be made upon the termination of the present Conciliation Board general wage rate agreement. The National Federation are also being asked to deal with the relationships between the Enginemen, Stokers and Craftsmen's Association, and the Gas Workers' Union, and the Federation. The men at the Bedwas Colliery—the stoppage almost resulted a few weeks ago in a general strike in South Wales—have not yet returned to work. While they admit that the settlement effected is satisfactory, they now maintain that there are still some defects in the working arrangements of the mine, and for that reason they are still out. The miners' leaders, however, are dealing with the matter, and it is hoped that by next week the trouble may be over.

BUILDING SCHEMES.—The Ministry of National Service have announced that, as from the 21st inst., the requirement of licences for building schemes is cancelled.

BY-PRODUCT AND BEEHIVE COKE IN THE UNITED STATES.—In the week ending November 2, by-product coke production in the United States was estimated at 577,000 tons, and the production of beehive coke at 558,000 tons.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 3, at 7.30 p.m., at 39, Victoria-street, Westminster, S.W., a paper will be read on "Concrete Ships," by Mr. P. M. Fraser, A.R.I.B.A., Member.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Tuesday, January 7, at 7.15 p.m., at the Mining Institute, Neville-street, Newcastle-on-Tyne. Paper on "The Design of High-Speed Generating Units," by Mr. G. Bonner.

THE RÖNTGEN SOCIETY.—Tuesday, January 7, at 8.15 p.m., at the Royal Society of Arts, 18, John-street, Strand, W.C. A paper will be read by Mr. H. S. Allen, M.A., D.Sc., "Electrical Changes Produced by Light."

INSTITUTE OF MARINE ENGINEERS (INCORPORATED).—Tuesday, January 7, at 6 p.m., at the Minories, Tower Hill, London, E. 1, Mr. J. T. Milton will deliver the Presidential Address.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, January 8, at 8 p.m., at the Royal Institution, Colquitt-street, a paper will be read by Mr. G. W. Daniels, M.Eng.(L'pool), entitled "Some Recent Developments in the Theory and Practice of Refrigerating Machines."

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, January 8, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2, Mr. L. H. Pomeroy will read a paper on "Influence of Valve Lift and Combustion Chamber Design on Consumption."

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, January 8, at 7.30 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C., a paper will be read by Mr. J. H. Anderson, M.I.Min.E., on "The Transport and Handling of Fuel," illustrated by lantern slides. Mr. W. H. Booth, F.G.S., M.Am.Soc.C.E., in the chair.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, January 9, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Lecture: "The Navigational (Magnetic) Compass as an Instrument of Precision," by Mr. M. B. Field, O.B.E., Member.

THE BIRMINGHAM METALLURGICAL SOCIETY.—Thursday, January 9, at 7 p.m., at the Birmingham Chamber of Commerce, New-street. Paper by Mr. Harry Etchells, B.Met., M.Inst.M., "The Functions of the Electric Furnace in Modern Engineering Practice."

UNIVERSITY INTELLIGENCE.—Short courses on town planning and housing, under the direction of Professor Stanley D. Adshead, M.A., F.R.I.B.A., have been arranged at the suggestion of the Local Government Board. These courses will be open to men who have had at least three years' training as architects, and who have been serving with H.M. Forces. Applicants for admission must submit evidence satisfactory to Professor Adshead, including, if required, specimens of their work, to show that they have had the requisite previous training. Each course will consist of lectures and studio work. Special lectures will be given by Professor F. M. Simpson, F.R.I.B.A., Professor E. R. Matthews, A.M.Inst.C.E., Mr. Raymond Unwin, F.R.I.B.A., of the Local Government Board, and Mr. L. R. Abbot, clerk to the Urban District Council of Ruislip, Northwood. Further particulars may be obtained on application to the Secretary, University College, London (Gower-street, W.C. 1).

BLEACHING POWDER FOR USE IN HOT COUNTRIES.—While the use of hypochlorite solutions for surgical purposes and disinfection has much spread during the war, increasing trouble has been experienced from the slow decomposition and weakening which the hypochlorites undergo in hot atmospheres. The hypochlorite used is either electrolytic sodium hypochlorite, or the calcium salt known as bleaching powder. In Alexandria bleach assaying 11 per cent. of available chlorine is considered as still of good quality. The average temperature there is 93 deg. F., and at that temperature, Drs. T. Rettie, J. Lorrain Smith and J. Ritchie (*Journal of the Society of Chemical Industry*, December 16, 1918), found, a bleach originally of 34 per cent. was reduced to a strength of 1 per cent. in eight weeks, while at 113 deg. F. the available chlorine had completely disappeared in three weeks. As it is impossible constantly to analyse the bleach again in order to state how much of it should be used, they attempted to stabilise the bleach in the first instance by drying it. Chlorine was lost during the desiccation, however, and the product was hydroscopic and absorbed moisture again. They then mixed the powder with an absorbent, and they found freshly-ignited quicklime suitable for this purpose. A mixture of bleach and of a sufficient amount of quicklime to bind the moisture in it (or a little more lime) lost only 9 per cent. and less of its 33 per cent. of chlorine under conditions when the untreated bleach would completely have become useless. Good bleach should contain 36 per cent. or 38 per cent. of available chlorine; during the war the standard has gone down to 35 per cent. and lower, however. One of the chief uses of hypochlorite is for the sterilisation of drinking water. As regards this use serious complaints came particularly from the Mediterranean area, chiefly owing to the fact that the deterioration gives rise to the formation of chlorate, which has an unpleasant taste and is certainly injurious when more than the customary amount of hypochlorite has to be added to the water because the disinfection is otherwise incomplete.

THE PILKINGTON SPECIAL HOSPITAL FOR DISABLED SOLDIERS AND SAILORS, ST. HELEN'S.

(*For Description, see Page 6.*)

FIG. 9. THE WARM POOL FOR HYDRO-THERAPY.

FIG. 10. THE ROOM FOR REMEDIAL GYMNASTICS.

FIG. 11. THE RE-EDUCATIVE WORKSHOP; WOODWORKING.

FIG. 12. THE RE-EDUCATIVE WORKSHOP; CLAY-THROWING.

THE PILKINGTON SPECIAL HOSPITAL FOR DISABLED SOLDIERS AND SAILORS, ST. HELEN'S.

(*For Description, see Page* 6.)

FIG. 1. THE RECORDS ROOM.

FIG. 2. THE RADIO ROOM.

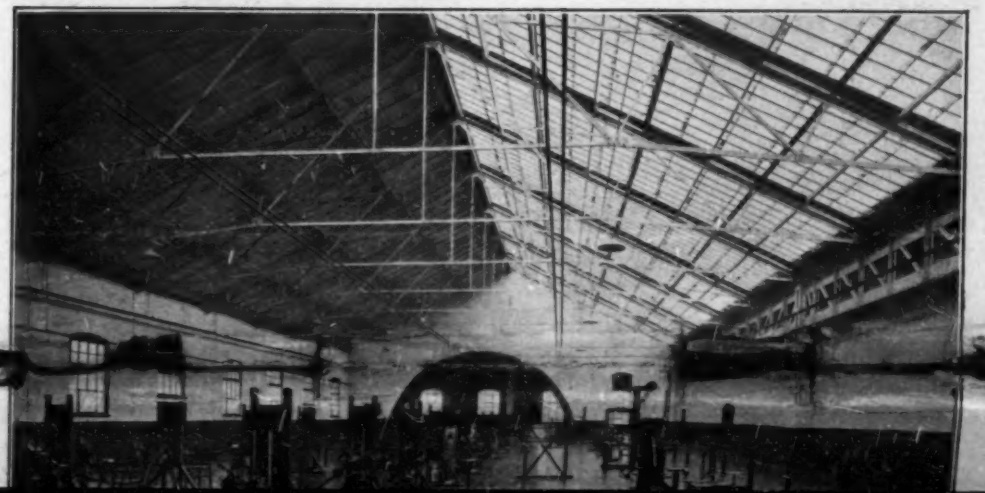


FIG. 1. THE RECORDS ROOM.

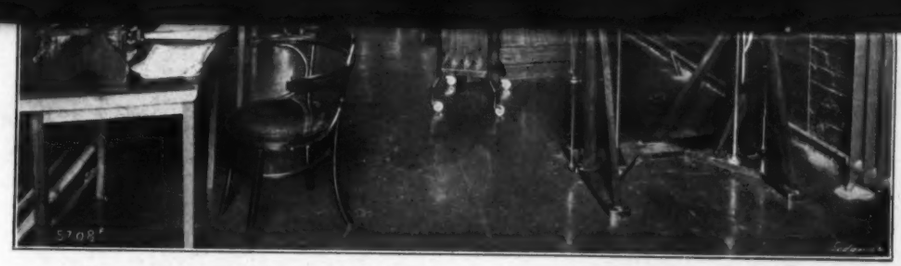


FIG. 2. THE RADIO ROOM.

FIG. 3. THE OPERATING THEATRE.

FIG. 4. THE HALL FOR MECHANO-THERAPY.

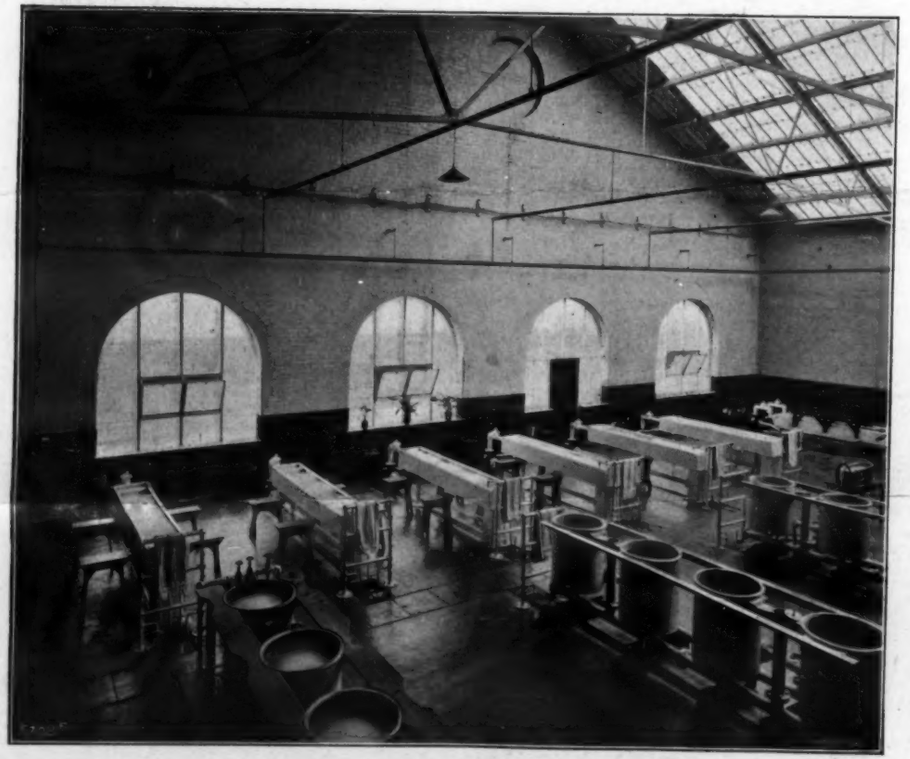


FIG. 5. THE HALL FOR HYDRO-THERAPY.

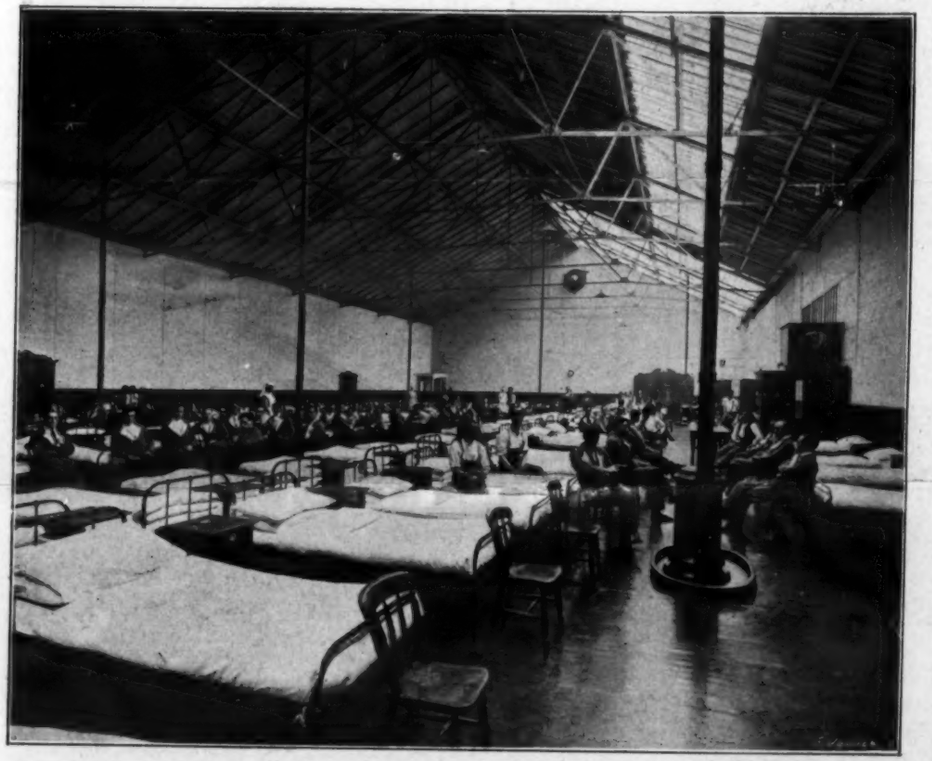


FIG. 6. ONE OF THE WARDS.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

SUBSCRIPTIONS, HOME AND FOREIGN.

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With a Two-Page Plate of the PILKINGTON SPECIAL HOSPITAL FOR DISABLED SOLDIERS AND SAILORS, ST. HELEN'S.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 6d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 15.

ENGINEERING.

FRIDAY, JANUARY 3, 1919.

THE NEW WORK OF THE NEW YEAR.

WE begin the New Year with a new Parliament and with new constructional problems of great magnitude to solve. We have little faith in the constancy of resolutions dictated by the calendar, but at the present time the conditions are so abnormal that new propositions are essential to the maintenance of industrial and social life. The disorganisation consequent on 4¼ years of war has been so great that far-reaching endeavour is imperative if we are to regain our old position, and still more is demanded if we are to make the developments necessary to compensate for the sacrifices of the recent past. It is appropriate therefore that the legislature, upon which so much depends in the fulfilment of our national resolution, has been rejuvenated by the incidence of a general election; has been given, with unmistakable decision on the part of the electorate, a definite guidance as to what the great mass of the people desires, and a mandate to carry the national hopes to full fruition.

We are not here concerned with politics except so far as they influence industry, but it is difficult to-day to dissociate the two, because the chief function of the new Parliament will be the reinstatement of peace industries on correct and commonsense lines. It therefore becomes pertinent here to indicate the two clearly defined lessons taught by the election, especially as these lessons must tend very largely to influence the future of industry, if their teaching be brought into full effect. One emphatic result is that the great mass of the people have decided that those problems to be solved by Parliament shall be considered in future without reference to the party predilections of the past—that each case must be considered on its merits without regard to bygone shibboleths. The second and equally decisive fact established by the polling of votes is that the international element in labour organisation is not acceptable to the trade unions, far less to the people of the country. No manipulation of the ballot-box can establish the claim, long put forward, that there is other than a small section of workers in the country in favour of the extreme measures advocated by a few; the leaders of this small but clamant faction have been dismissed from Parliamentary life, and there is no more hopeful augury for a new era in British labour than these and other contemporary incidents.

The first essential towards the reorganisation of industry is to establish a spirit of mutual trust on the part of the employer and worker. It has been said that there is nothing so barren as suspicion. Certainly never before in the industrial history of this country have employers shown a more earnest desire, supported by a readiness for willing action, to meet the claims of labour for a fuller share of the rewards of prosperity. There was a fear that this approach to a greater sympathy would be met on the part of the extremists in the ranks of the workers by such excessive demands as would make impossible better conditions for the future. We are encouraged somewhat by recent results to believe that the extremists are fewer in number than was feared, and that if trade unionism will get rid of the incubus of some of their self-appointed leaders, it will be easy to solve, to the immense advantage of all the workers, many of the difficulties which have fertilised the seeds of discontent. But the one thing needful is that the joint interests of employer and worker should be mutually considered and settled with the absolute minimum of Government interference or direction. Even on the principle of "diamond-cut-diamond" it is well that two opposing parties should themselves work out the solution of their problems. It is a mistake to assume that in conference opposing ideas cannot find converging lines and agreement. In any event, it is to the good that there should be a direct, honest, clearly-defined statement of opposing views, and that there should be cultivated the requisite spirit of seeing the other side's point of view. The Whitley Committees, we are convinced, will have immense influence in this direction; and now that it has been established that the extremists in trade unionist ranks are in inverse proportion to their volubility, we are hopeful that even the most pronounced opponents of such committees amongst trade unions will realise that the vote of the majority must be operative.

The national as well as the individual need is for increased production for a given expenditure in wages, charges and profits. We are not concerned here with indemnities or compensation for war expenditure, but we are concerned with those taxes which handicap industry. The primary need is to bring back the value of the sovereign to its former high level, and this can only be done by increased efficiency in transport, manufacture and distribution. Labour takes a large toll in all three respects, and it is imperative that this labour should be made more efficient, and therefore contributory to the reduction in final cost to the consumer. To achieve this a high degree of mentality in the managerial staff is the first necessity, associated, as it must be, with mechanical appliances to decrease manual effort and make it more productive. As a natural consequence there must be encouragement and development of invention, a recognition of the value of improvements, and a willingness to utilise these to the fullest possible extent. There is no doubt that the policy of restricted production in the past has been inimical to all these essentials to efficiency, and the attitude of the trade unions in this respect has tended very considerably towards hesitancy to embark on new plant, if not to the cultivation of a complacency on the part of those responsible for industry which has seriously handicapped our national endeavours towards industrial expansion. We are willing, even ready, to recognise that the trade unionist has had some justification for his attitude, because there is no spectre so gaunt to the worker as the threat of unemployment through over-production. Whether there can be a national scheme to provide against this contingency is a matter which need not here be discussed; but it is desirable that workers should be educated on correct lines regarding the advantage of economical production, because without this we cannot get rid of the immense burden of war debt and cannot hope to succeed in the future in extending our foreign markets for the absorption of our manufactures. If our international competitors in the future—the names will readily suggest themselves to our readers—succeed in producing goods at a less cost than Britain, obviously they will be able to find markets for their goods, and it follows inevitably that there will be less employment for our workers. There is no other way of guaranteeing full-time occupation than by economical production, and this can only be achieved by ensuring the highest efficiency. It should be enforced further that this means high earnings, whatever be the method of computing the rate of remuneration for the worker. Every employer must be prepared to provide the best conceivable design of manufacture, the most effective mechanical producing appliances, and the greatest possible enterprise in cultivating foreign markets. Every worker must realise it to be his duty, first, and most important, to himself, and

second to the nation, to make the best use of these appliances and to secure the greatest output.

It may be asked how the new Parliament can assist towards the accomplishment of the duties of the employer and the worker. It certainly cannot be done by syndicalism, because the individualism which has done so much in the past, especially in science and industry, finds its greatest encouragement to expansion in the stimulus of immediate reward due to industrial success. It cannot be done by nationalisation, because it has been recognised in the few undertakings of the State that there is a supineness in State officials, an inertia which cannot be overcome, the blighting effect of which withers all effort and enterprise. It cannot be done by Government control, because there is an absence of direct contact with the two great partners of industry, and often a disregard to the immediate requirements of emergencies and, indeed, of normal procedure. It can be done by State encouragement—for instance, by the support of research and experiment under clearly-defined freedom of action. We cannot in the future, as in the past, allow all other nations to do to us what we are precluded by treaties from doing to them. To begin with, great new industries must be created, in order that the factories built to meet war emergency may be occupied in labour-utilising trades. Similarly, we must make for ourselves all those items which are essential to great industries, but which in the past we have bought from foreign countries. Many of these might be enumerated; the manufacture of dyes serves as an illustration. In order that these new industries may be established, it is desirable that the Government should as soon as possible indicate the method and extent of the encouragement to be given. It is a difficult problem, but the committee presided over by Lord Balfour of Burleigh considered it, and made the proposition that all such cases should be judicially dealt with on their respective merits by an advisory committee reporting to Parliament. The sooner the new Parliament accepts some such scheme, the more expeditious will be our commencement of such new industries. Another important problem which must be tackled at the earliest possible moment has relation to the recovery, transport and distribution of raw materials. In the past the State has been rather careless regarding these, and here again prompt action is necessary.

Immediate decision is called for because there is scarcely a large firm in the kingdom which to-day is not anxiously exercised regarding the arrangement of post-war industry. Many of them have built and equipped great factories to meet the requirements of the Ministry of Munitions. These factories have been giving employment to an immense army of workers. With the termination of the war the demands for the products of those shops has ceased, and if the great army of munition workers is to be turned, as is most desirable, into producers of peace manufactures, marketable in foreign countries, it is essential that the firms owning these factories should have early enlightenment, as well as full encouragement, in determining the exact nature of the manufactures of the future. Time is an important element in the problem, and not a single day should be lost by the new Parliament and the new Government in giving a direct lead to those firms who are ever anxious to maintain in full and pleasurable employment the staff of workers enlisted in their ranks and worthy of being retained therein by reason of their individual efficiency.

THE RAILWAY PROBLEM.

In commenting upon the railway problem in our issue of December 20, we emphasised two points: (1) That the whole facts of the situation must be set before the public in order that the Government policy and methods may be known and appreciated before the State is committed one way or the other; and (2) the need of furnishing information to enable any business man to form a sound conclusion on the merits of the case. To these points we now propose to give further consideration, regarding the matter purely from a business aspect. In our opinion the business point of view is the predominant, if not the only, consideration. The commercial community and the taxpayer must be alert to see that the Labour-Socialist nationalise-everything ideas do not unduly sway the new Government on the one hand, nor the railways-are-bankrupt-and-must-be-bought-by-the-State argument on the other.

In recent months there have been many references to the future of railways, the most important being Mr. Winston Churchill's very casual statement at a political meeting that the Government had definitely made up its mind to nationalise the railways. Others who claim to be more or less "in the know" have credited the Government with possession of a cut-and-dried scheme for a Ministry of Transport, with Sir Eric Geddes at its head. Without attaching too much importance to any of these statements, we may point out that should the Government establish such a Ministry they would be taking the sanction of Parliament to the nationalisation or control of the railways as being merely a matter of form—yet Parliamentary sanction is necessary even to the continuance of the present control. This brings us to a pledge that was given in the House of Commons by Sir Albert Stanley, the President of the Board of Trade, in November, 1917. Just before that date another pledge had been given by Sir Albert Stanley to the Associated Society of Locomotive Engineers and Firemen in regard to the men's demand for an 8-hour day. So carefully has that pledge been kept that not only have the enginemen and firemen been given the 8-hour day, but all other grades of railway employees have been embraced in the concession. We may infer from this manifest regard for the sanctity of pledges that Sir Albert Stanley will see to it that the pledge to the members of the House of Commons will also be honoured. According to *The Times* of November 15, 1917, Sir Albert Stanley, replying to Mr. Gilbert, who asked whether a committee had been appointed to consider the position of the railways after the war as regards either State purchase or continuing the present Government control, said: I am afraid there has been some misapprehension in connection with this matter. The Board of Trade, in consultation with the Ministry of Reconstruction, are giving close attention to the problems that will arise when the present war control of railways ceases. In connection with various aspects of these problems, the Board are being advised by a number of gentlemen possessing expert knowledge or experience. The names of these gentlemen are as follows: Mr. W. M. Acworth, Mr. W. W. Berry, Sir John Bradbury, Sir Gilbert Claughton, Sir Thomas Ratcliffe Ellis, Mr. Kenneth Lee, Sir Ernest Moir, Mr. Ernest Moon, Sir William Plender, Mr. F. Potter, Sir David Shackleton, Sir H. Babington Smith, Mr. H. Steel, Mr. J. H. Thomas, Sir Herbert Walker, Mr. Sidney Webb and Mr. A. W. Wyon. They do not, however, constitute a formal committee and there are, therefore, no terms of reference. He (Sir A. Stanley) further said that he had no hesitation in giving an assurance that the House should be consulted before any final arrangements were made. It will be for the representatives of the commercial community in the newly-elected House of Commons to see to it that this pledge is fully honoured.

Our next point has reference to what may be described as essential data as to the work that has been done by the railways and their exact financial position during the war. It is a curious feature that while much has been said by members of the Government, by chairmen of railway companies and others in regard to what the railways have done during the war, the estimated (not actual) cost of war bonuses and concessions to the men, &c., there has been what might be described as a conspiracy of silence in regard to accounts and statistical data. Compliments have been numerous. They have usually been in some such terms as these, which we quote from the War Cabinet Report for the year 1917: "In a period of strain and difficulty the railways of the country and those responsible for their management and operation have risen to every call upon them. Whilst filling all the huge requirements of the war they have, in the frequency of passenger trains, their comfort and rapidity, and in the regularity and quickness in the carriage of goods, provided for the civil population a service probably superior to that of any other country, allied, neutral or enemy." This is all very nice, but the business man desires to know whether the successful operation of the railways during the war has been because of Government control, or in spite of that control. One thing is certain, there has been no Railway Controller! The Railway Executive Committee consists of general managers who meet, we believe, weekly. There is no large staff; it is modestly housed at 35, Parliament-street—not in a palatial hotel. The railways have been managed by their pre-war boards of directors and managers, the outstanding feature being a general desire to assist the State in every possible way in their war effort. In saying this we have no desire whatever to minimise the part that has been played by the Railway Executive Committee. The regular meeting together of the managers who sit upon it must have been of the greatest possible assistance in every way; but this co-operative tendency was in evidence before the war and it has been developed by what has happened during the war. Moreover, as in all professions and trades, lessons have been taught by the war that will permanently affect future operations, the principal—in the case of the railways—being that rolling-stock maybe interchanged between the lines on a much broader basis than in pre-war days. This, in turn, has brought into prominence the desirability of standardised parts for locomotives, carriages and wagons and their manufacture in bulk instead of by individual companies. These benefits could be secured whether the railways are owned by the State or not; the one thing that could alone be secured by nationalisation is the complete cessation of competition, and it is for the commercial community to say whether it desires to be rid of all that has been involved in the competitive system of railway operation. That more will have to be paid for transportation—either by way of taxation or by increased rates and charges—seems to be inevitable in view of the enormous growth of the railway wages bill and other causes, unless offset by economies. But to enable the financial position of the railways to be gauged with any degree of precision it is important to know what the maximum traffic capacity of the railways as they now exist is: the revenue at present rates represented by the maximum traffic capacity and the expenditure involved in maintenance and operation. If we are to accept all that has been said about the traffic that has been conveyed by railway during the war it would seem to be safe to assume that it has reached the maximum. Therefore what we desire is to secure publication of facts, not estimates, in regard to the war period. Here it is necessary for us again to quote Sir Albert Stanley. As President of the Board of Trade he is *ex officio* chairman of the Railway Executive Committee, his department has made all the various agreements and arrangements with the railways and, therefore, must be in possession of full information as to the traffic receipts of the railways, the extent of the Government traffic that has been conveyed without charges being raised and the amount paid to the railways as compensation under the terms of the agreement with the Government. The last considered statement by Sir Albert Stanley in regard to the railways was made in the House of Commons on May 15 last. From it we gather the following: It is now a common practice to operate much heavier trains, and the loading per wagon is very much heavier than it was prior to the war. The traffic on the railways, both of goods and of passengers, has been heavier than at any other time in the history of the railways. "It is really very remarkable," said Sir Albert Stanley, "that at a time like this, when we realise the number of men who have been withdrawn from the country, that the railway companies should find themselves carrying more passengers, *quite exclusive of military account*, than they have ever carried before, and that the goods traffic, *quite independent of traffic on Government account*, is also heavier than at any time in their history." The italics are ours and are of importance because, as Sir Albert Stanley explained, "All the traffic carried by the railway companies on Government account is not entered into the account of the companies." We shall show the enormous range of traffic carried free on Government account, but before leaving Sir Albert Stanley's statement we

would quote one piece more. He said: "A careful calculation to-day and since the last increase to employees' wages was made will disclose that the bargain will show a loss to the State. The railway companies have not since the war made any increase to their charges for carrying goods. Of all the big services this is the only one where no increase in charges has been made during the war. Up to the present this has only been possible very largely because of the enormous economy due to the unified system of control." The wages bill was then estimated to have increased by 47,000,000*l.* per annum: the railways were carrying more traffic, exclusive of Government traffic, than ever before (presumably the estimated value of the Government traffic was known); enormous economy had been effected thereby justifying pre-war goods rates—yet in May last the bargain with the railways was said to be a loss to the State. If this is the kind of information that is to be placed before the House of Commons to enable it to form a sound judgment as to the railway problem it will be for someone to speak out very plainly. As Sir J. Bethell subsequently said: Most people were under the impression, having regard to the heavy traffic, that the railways were making a profit. He would have liked to see a statement showing the income and expenditure for last year and the losses incurred. That is the point, and it must be met. In our last issue we gave statistics of the pre-war railway traffic, including the number of passengers carried, the weight of goods and minerals conveyed. Sir Albert Stanley has asserted that, exclusive of Government traffic, those totals have been exceeded. Now, there is no possible reason why the Government should not publish the total receipts of the railways for traffic other than that carried free on Government account. The figures are known to the Board of Trade, as without them the amount of compensation payable by the Government cannot be determined. We may recall that to ascertain the compensation payable, the aggregate net receipts of all the railways taken over by the State is compared with a similar aggregate for the corresponding period of the year 1913. The ascertained deficiency is the amount of compensation due. It need not be said that before the net receipts can be ascertained the gross receipts and gross expenditure must also be computed Therefore, the Government know (1) the total railway receipts, (2) the total railway expenditure, (3) the total net receipts, and (4) the amount that has been paid in order to make up the deficiency as compared with the year 1913. That information must be disclosed in order to show the basis of Sir Albert Stanley's statement in regard to record railway carryings. To anticipate an inquiry why individual railways have not published the facts in regard to their respective systems, we may say that they do not know. When the railways were taken over by the State and the agreement regulating compensation had been made, it was unnecessary to do what is technically known as "divide" the traffic. Each company accounts for the money it actually takes; if the balance exceeds its net receipts for the year 1913 the surplus is paid to the Railway Executive Committee and is used in payment of the compensation to the companies whose net receipts are less than for the year 1913. Division of traffic receipts in pre-war days was made by the Railway Clearing House, and its abolition has necessarily effected much economy. The result, however, is that no one company knows how it really stands financially; it may be conveying much more traffic, but it does not know accurately how much would be its correct proportion of the receipts. This is known only in respect of all the railways when the receipts and expenditure of all the companies are thrown together in the manner already described.

We now come to the question of Government traffic, and we believe that very few people realise that practically no cash payments are made to the railway companies for all the services they render to the various departments of the State. Therefore, while it is known to the Board of Trade what amount has to be paid to the railways to make up the deficiency of net receipts, it is not essential to compute what would have been the traffic charges that would have been payable had the Government paid their traffic account in the same way as any other user of the railways has to. It follows, however, that in the absence of this information it is impossible to say whether the bargain between the State and the railways has been in favour of the State or not. Sir Albert Stanley has said that "estimates are made from time to time, but they are only rough estimates." We cannot believe that so haphazard a state of affairs can exist as that persons and goods can be sent by railway without some documentary evidence of the numbers, weight and distance to be conveyed. If we are correct in this respect something more should be possible than the preparation of "rough estimates." That the Government traffic must have been immense is evident when it is borne in mind that not only have soldiers, sailors and naval and military stores been conveyed free, but the Admiralty, War Office, Air Ministry, Ministry of Munitions, Board of Agriculture and Fisheries, Ministries of Food, Labour, National Service, Shipping and practically every Department of the Government has authority to use Government conveyance notes or similar authorities for carriage of goods or parcels by goods or passenger train without prepayment and to return to the railway company concerned any account for goods or parcels traffic endorsed "certified to be a Government liability" in lieu of making a cash payment. The carriage of millions of tons of munitions traffic has been franked by conveyance notes, and millions of journeys have been made by railway on the basis of free passes or vouchers issued by Government departments. That this has led to unnecessarily long haulage of traffic is well known to those who come into contact with railway officials; as also instances of long journeys by government officials, when a letter or conversation by telephone would have met the necessities of the case. Full information—not rough estimates—of the extent to which the Government have used the railways without direct payment is necessary to demonstrate the traffic capacity of the railways, the financial result of the agreement with the railways, and to ensure that in the event of State purchase railway shareholders shall have fair and equitable treatment. The Government of the United States were able to profit by the mistakes of other countries, and it is noteworthy that when the railways of that country were taken over it was decided that the Government departments should continue to pay the Railroad Administration for the carriage of their traffic. Mr. McAdoo, in his capacity of Director-General, said that this was to enable accounts to be kept in the usual manner, so that a proper record might be secured. In a recent review by Mr. W. M. Acworth, of the Federal Railroad Administration of the United States, he refers very pointedly to the desire of the new administration to know, and to let the public know, what the railroads spend, what they earn, and how far they are a charge on the Treasury. The public in this country are equally entitled to have these data: indeed, too long have they been content to accept vague generalities and the suppression of publication of all accounts and statistics in order to save a few tons of paper! We suggest that a demand should be made for definite statistical data to be published by the Board of Trade under the following heads for the period August, 1914, to December, 1918:—

Total receipts of controlled railways.
Total expenditure of controlled railways.
Net receipts of controlled railways.
Amount paid by the Government as compensation.
Amount included as expenditure in the accounts and paid by the Government in respect of arrears of maintenance expenditure.
Particulars of all sums paid by the Government other than in respect of deficiency of net receipts; such as interest on capital expenditure that has become productive during the war, &c.
Value of services (with particulars of such services) rendered by the railways to the Government in respect of which no payment—or part payment only—has been made.
Actual cost of the war bonus and other concessions granted to railway employees during the war.
Each company should also be asked to give particulars of its train mileage—passenger and goods; numbers of passengers and tonnage of goods conveyed; average length of haulage; average train and truck load, and receipts per train-mile. With these data the business man will be able to form something in the nature of a sound judgment as to the present financial position of the railways and the extent to which those who use the railways must pay increased charges in order to counterbalance increased expenditure.

THE ONE-BREAK DAY.

AMONG the industrial changes which have taken place recently one of the most important from all points of view is that which reduces the number of hours constituting a working week in shipbuilding and engineering establishments from 54 to 47 per week. The demand for a working week of 48 hours has long had a prominent place in the aims of trades unionists—particularly amongst engineers—while the shipyard workers have, through their unions, recently put forward a demand for a 44-hour week. As a result of conferences between representatives of the employers and the trades unions concerned it was agreed to recommend to the workers the acceptance of a 47-hour week subject to certain guarantees as to remuneration of time workers, &c. By a considerable majority the workers have, by ballot, accepted the recommendation and the 47-hours' week now becomes the standard for these industries. In its practical application the new arrangement will in general mean the working of 8½ hours per day in spells of 4¼ hours on five days per week and 4½ hours on Saturday, with a break of 1 hour between spells on week days, whilst the starting hour will be about 8 a.m. instead of 6 a.m. as at present.

The changes involved in giving effect to the new arrangement will be somewhat drastic and must meantime be regarded as tentative, but it is not without interest to consider briefly some of the probable effects of these changes.

It is now accepted by all authorities that long hours of labour for the worker is an economically unsound proposition—indeed, scientific investigations carried out by the Ministry of Munitions conclusively proved that in some cases a reduction of the number of working hours corresponded with an increase in production. The number of hours which constitutes the economically ideal working day for any class of manual worker must of necessity be to a large extent dependent upon the physical exertion demanded of the individual worker, assuming that each works up to the limit of his capacity. The physical exertion demanded of, say, a tool store keeper is, however, in no way comparable to that required of a hand riveter for equal intervals of time where each works at his maximum capacity.

In practice the hours of labour are the same for each, and it naturally follows that whatever the number of hours fixed upon it is at best only a compromise in which the more physically strenuous trades seek to adjust matters by working at less than their maximum capacity. Whether the arrangement now decided upon will have the effect of intensifying effort over the shorter working hours or will merely result in a diminution of output corresponding to the reduction in working hours remains to be seen, but the factors favourable to the new arrangement are certainly of sufficient weight to justify the experiment and a belief in its ultimate benefit to workers and employers.

On all hands it is agreed that increased production is an essential to the successful re-establishment of our industries, and as this would appear to be inconsistent with a reduction in working hours it is of interest to look closely at the known factors of the situation in order to arrive at a reasonable estimate of the probable effect of the new conditions upon output.

The actual loss of working time per week is, on paper, 7 hours, but the abandonment of one meal hour per day for six days should mean a gain of about ½ hour of actual working time per day due to the elimination of the slack period before and after the meal time stoppage. This reduces the loss of working hours to, say, 4 per week, or about 7½ per cent. It seems certain that the amount

of broken time will be considerably reduced under the new arrangement and as a result a considerable gain should accrue owing to the increased number of hours worked per week by the same number of employees for the same oncost per hour as at present. It is to be noted also that the provisional agreement reached by the representatives of the employers and the trades unions in conference, and in accordance with which the new arrangement is being instituted, provides that no change shall be made in piece-work prices as a result of the shorter hours. This would seem to indicate a belief in the view that little difficulty will be experienced by piece workers generally in maintaining their present earnings—a view which finds ready acceptance amongst those in a position to assess the actual and possible output of the workers. The position of the time worker is less satisfactory from the point of view of general works economy and efficiency, for in his case the likelihood of increased output, except in so far as that may be due to better time-keeping, is small, while his earnings per hour are increased by about 15 per cent.

The employment of the most efficient methods and a sufficiency of the most economical machinery are the means by which the employer must counteract this deficiency, and these if allied to a genuine effort on the part of the workers will go far to restore the economic balance.

On the whole, there does not seem to be any reason to fear that output will drop seriously in the case of those engaged upon direct manual work and upon operations involving the use of light pneumatic and electric machines such as are used in shipbuilding operations. Punches, sheering and flanging machines and other heavy machinery of the shipyard are seldom worked at anything like their full capacity, and in general no difficulty should be experienced in meeting the new conditions so far as they effect the shipbuilding plant. The case of engine works where large and expensive machines are employed presents a less favourable aspect, for it has always been the aim of the employer to ensure that such machines were kept employed at their maximum capacity. Generally speaking, such machines are in the hands of the best and most trusted workers, and any hope of improved output from them must be slight. The timekeeping of the men employed in the shops is also as a general rule better than that of the shipyard worker employed in the open, and the same improvement in output due to improved timekeeping is not therefore to be looked for. Payment by result in one or other of the various systems of premium bonus is very general in engine shops, and as the terms of the new agreement provide that premium bonus earnings shall be calculated on enhanced day-shift rate the indications are in favour of higher earnings for the men for a smaller output.

The success or failure of the scheme as a whole rests almost entirely with the workers. Elimination of avoidable lost time and a frank recognition of the necessity for increased production for increased pay will ensure the success of the new departure and may justify still further reduction in working hours. On the employers' side efficient organisation, up-to-date plant, and an honest effort to gain and keep the confidence of his workers are equally necessary, and given these conditions on both sides the success of the scheme of reduced working hours should be assured.

The modifications in domestic routine involved by the change to the one-break day are considerable and may require special consideration if the benefits expected from the system are not to be sacrificed. It is essential that the worker should have a thoroughly good meal before commencing work for the day, and where the majority of workers live close to their place of employment no very great difficulty is presented by the problem of breakfast at or about 7.30 a.m. It is, however, the case that a large and increasing number of workers in the larger establishments travel daily to and from their work by train or tram car, and in many cases a journey of at least half an hour is common. This would necessitate the provision of breakfast in the home before 7 a.m., and in many cases it is to be feared that the provision made for this would be totally inadequate. As an alternative it might be possible to arrange for breakfast at one of the numerous restaurants usually to be found in the vicinity of large works provided the travelling facilities were such as to allow of time for this. One probable advantage of this would be that the time between breakfast and dinner would be reduced to the minimum. The most satisfactory solution would probably be found in an extension of the canteen system at present in operation at some works, and this solution of the difficulty is certainly worthy the most serious consideration of both employers and workers for no man can be expected to give 4½ hours' good work unless he has previously had a nourishing meal. The interval of 1 hour for dinner should allow a larger number of men to have this meal at home, and to this end travelling facilities should be arranged on the most adequate scale. For those unable to travel home the canteens would provide satisfactorily, or failing these, the local restaurants. The provision of adequate meals is essential to the success of the one-break day, and where it is found that these cannot be supplied at home arrangements must be made to supply them in or near the works.

Whether the present arrangement of the reduced working hours is the most suitable time alone will show, but as an earnest attempt to better working conditions the arrangement is certainly worthy an extended trial.

THE CROSSING OF THE ATLANTIC BY AIR.

THE developments in aeronautics have been so rapid, owing to the impetus given by war conditions, that the question of establishing connection between the various continents, in particular between America and Europe, would seem to be within measurable distance. The public interest has latterly been roused by the press, both technical and otherwise, in this possibility—but whilst the case of the aeroplane has been very often referred to with a view to use after the war for commercial purposes, mention is seldom made of the possibilities of the lighter than air means of aerial locomotion. This is probably due to the fact that the capabilities of airships are not so well known as in the case of aeroplanes. It will be readily understood from the considerations put forth in the following notes, that whilst the crossing of the Atlantic by aeroplane is a very difficult performance, unless special intermediate stages are provided, a modern airship is capable of negotiating the distance with ease. In fact, if Zeppelins had been built in America, instead of Germany, it is quite likely that the Atlantic would have been crossed by air at any time since 1915, when the 60-ton modern Zeppelin made its appearance.

The two factors which put the airship in such a favourable position for such long distance work are :—(1) The low value of the traction co-efficient of an airship as compared with an aeroplane ; (2) The capability of the airship of cruising at a moderate speed with a very small percentage of its power.

The speed of an aeroplane that would most likely be used for this purpose would be about 90 miles per hour, whilst an airship designed for this purpose would have a speed of about 65 m.p.h. Now, the traction co-efficient of the aeroplane at 90 m.p.h. would be 16 per cent., whilst that of an airship would not exceed 5 per cent. at 65 m.p.h., and would be less at lower cruising speeds.

If we take 30 per cent. of the gross weight of the machine as fuel in both cases, and $3{\cdot}2 \times 10^6$ ft.-lb. of energy available per pound of fuel, after allowing for propeller efficiency, we find that :—

In the case of the aeroplane :—

Total energy carried as fuel = $\cdot 3 \times W \times 3{\cdot}2 \times 10^6$ ft.-lb.
Resistance = $\cdot 16$ W.

$$\therefore \text{Maximum possible non-stop flights} = \frac{\cdot 3 \times W \times 3{\cdot}2 \times 10^6}{\cdot 16\ W}$$

$$= \frac{\cdot 3 \times 3{\cdot}2 \quad 10^6}{\cdot 16 \times 5280} \text{ miles} = 1136 \text{ miles.}$$

In the case of the airship :—

$$\frac{\cdot 3 \times 3{\cdot}2 \quad 10^6}{\cdot 05 \times 5280} \text{ miles} = 3430 \text{ miles.}$$

the range of the airship being over three times that of the aeroplane.

It will be seen that the range is inversely proportional to the traction co-efficient of the aerial machine, provided the same proportion of the engine fuel to gross weight is carried in both cases.

It may be argued that 30 per cent. of the gross lift is high, but it has been assumed that special arrangements would be made to ensure a maximum amount of fuel, and that every sacrifice would be made in other respects to satisfy the special conditions for long-range flights.

Lanchester gives a value of traction co-efficient of 10 per cent. as being the minimum limit of possibility for an aeroplane that might be designed in the future with special precautions to reduce the resistance to a minimum, the speed being taken at 90 m.p.h. Under these conditions, and with 33 per cent. of gross weight as fuel, he calculates that the possible non-stop flight for an aeroplane is 2,000 miles. This figure could, no doubt, be improved upon by using a slower speed, but other considerations would probably render this course inadvisable.

Since the distance to be covered is nearly 2,000 miles, we may definitely state that attempts at non-stop crossing of the Atlantic can only be regarded as freak performances, and that any serious attempt to establish flying routes across this ocean must involve, at least, one calling station *en route*. Particularly would this be apparent if an attempt were made to cross from Europe to America, as in this case the general easterly drift of the atmosphere would have to be encountered. This drift of the atmosphere may make it possible to make a non-stop flight from America to Europe, but before we can say that a flying route has been established, we should reckon upon the return journey being possible.

The position of a modern airship is much more favourable and is such that even with existing Zeppelin airships, given reasonable conditions and carrying not more than 25 per cent. of their own gross weight as fuel, the non-stop flight could be accomplished either way, particularly if advantage were taken of cruising, say, at half-speed, utilising only about one-eighth of its power, and consequently effecting economies in fuel used per mile.

Under these conditions of cruising at half-speed and carrying 25 per cent. of the gross lift as fuel, we find that the maximum non-stop flight is equal to :—

$$\frac{\cdot 25\ W \times 3{\cdot}2 \times 10^6}{\frac{\cdot 05\ W}{4} \times 5280} = 11{,}430 \text{ miles.}$$

The enormous advantage of an airship for long-distance flight is at once evident.

The following are the chief characteristics of an aeroplane and an airship that could be used with present-day knowledge and development for an attempt to cross the Atlantic in one continuous flight (of 2,000 miles) from America to Europe.

Aeroplane.	Airship.
Gross weight or lift 8 tons.	60 tons.
Useful lift ... 3·5 tons.	22 tons.
Maximum speed 90 m.p.h.	65 m.p.h.
Power ... ...1,200 h.p.	1,500 h.p.
Weight of fuel ... 3 tons.	15 tons.
Assuming that in ordinary circumstances, the engine power actually used would not exceed 1,000 h.p. in order to economise fuel—	
Fuel required per hour ... ... 500 lb.	Fuel required at full power per hour = 750 lb.
∴ hours of flight $= \frac{3 \times 2{,}240}{500}$ $= 13{\cdot}4$ hours	∴ hours of flight at full speed $= \frac{15 \times 2{,}240}{750} = 47$ hours
Neglecting the slightly reduced speed the distance covered in 13·4 hours = $13{\cdot}4 \times 90$ = 1,206 miles.	47 hours at 65 m.p.h. = 3,050 miles. The flight could therefore be accomplished without having recourse to cruising at low power and reduced speed and without the aid of assisting winds.
With an atmospheric drift of 30 m.p.h. assisting we have the total possible distance = 1,206 + 402 = 1,608 miles. So that unless the assistance from wind were greater, the attempt would fail.	N.B.—It is possible that the useful lift would be 30 tons and the fuel carried 20 tons, thus increasing the range in proportion to nearly 4,000 miles, and therefore capable of the non-stop double journey.

Assuming that the conditions for the aeroplane were

highly favourable and the journey from America to Europe were just accomplished, we see that owing to the atmospheric drift being against the direction of flight the return journey would be impossible under present conditions of design and performance.

With the airship, owing to its lower maximum speed, there would also be considerable difficulty in effecting the return journey if adverse winds were high, say, over 40 m.p.h. In this case, the effective speed would only be 25 m.p.h. at full power, and the time of flight required would be about 80 hours, and the journey could not be accomplished. If flight were made at half-power, and the speed reduced to 52 m.p.h., the effective speed would be 12 m.p.h., and the journey would take 166 hours, whilst the maximum time possible under these conditions would be 84 hours.

Cruising at reduced power against this adverse wind is, therefore, not helpful. The journey, however, could be accomplished if adverse wind did not exceed 20 m.p.h., as in this case the effective speed would be 45 m.p.h., and the time taken 44·5 hours, which is within the capabilities of the ship.

LITERATURE.

The Physiology of Industrial Organisation and the Re-employment of the Disabled. By Professor JULES AMAR, Director of the Laboratory of Physiological Research in the Conservatoire des Arts et Métiers, Paris. Translated by BERNARD MIALL. Edited with Notes and an Introduction by Professor A. F. STANLEY KENT. London: The Library Press, Limited. [Price: 30*s.* net.]

PROFESSOR JULES AMAR commands our respect and attention for his researches into the mechanical possibilities of the human frame, viewed as a simple machine. In "Le Moteur Humain," he has discussed the output of energy that the workman exhibits under various conditions, and demonstrated the methods by which the expenditure can be accurately recorded and measured. In this work an attempt is made to apply to practical ends the information thus acquired and systematised. Its object is to teach the hale man how, by eliminating useless motions and unnecessary fatigue, to accomplish his daily task with the smallest expenditure of labour, and further to enable the war cripple and the victim of industrial accident, so to play their parts in the economic tasks of to-morrow, that they may neither become a burden on the State nor sacrifice their sense of independence. It is needless to say that the appearance of such a book is eminently opportune. On all sides the need of a larger output of products is urged, the improvement of the conditions of human life is loudly insisted upon, organised defects and moral suffering are recognised as existing on a scale that has hitherto been denied or ignored, and the necessity for amendment or remedy is urged at a time when mutilation or chronic disability has reduced the economic value of millions of workers, and disorganisation has disturbed the working of customary procedure. At such a moment we need all possible assistance.

Since the economy of effort and the organisation of work occupy an important place in the author's programme, the system of Taylor naturally comes under review. When Taylor wrote his "Principles of the Scientific Organisation of Labour," which inculcated a system that aimed at the elimination of useless movements, and the substitution of a succession of orderly motions, he had not the wealth of observations that lie at the command of Professor Amar. Taylor could not analyse the complicated result, due to many factors, so completely as the author, but he was quite conscious of the ill-effects of fatigue, knew perfectly well the symptoms if he could not trace each to its source, and insisted on the discontinuance of labour when the ill-effects became visible. It would be a misfortune if the impression should be created that Taylor's scheme was unworthy of adoption, or its merits ignored, because its plan was empirical. Taylorism has found quite enough enemies in this country. Ignorance and prejudice have fought against the introduction of his main principles, and it is certainly with no little surprise, but with great satisfaction, that we learn from Professor Stanley Kent that Taylorism is now welcomed in the factories of both Europe and America. Whether the system as conceived by Taylor, and widened by Gilbreth, has a scientific basis, we need not stop to inquire. It may have resulted rather from trial and error than derived from the investigation of fundamental facts. It was an eminently practical scheme. It gave, or could ensure, to the workman, high wages, short hours of labour, and increased comfort. To the employer, it promised larger output and diminished working costs. Apparently both labour and capital could be benefited by the adoption of its principles. Why, then, has not Taylorism made more way? Why is it anathema to a certain class of trade unionists, and eyed doubtfully by capitalists? The answer provided by Professor Kent is scarcely satisfactory. He alleges that the indifference is due to early prejudice and inherent difficulties. Prejudice was roused by some of those with whom the fate of Taylor's system rested. "They lacked discretion and their methods, introduced unwisely were suspected, misunderstood, and rejected by the men. Had tact been used, and the workmen encouraged to understand the system, all would have been well."

We are afraid the true source of the objection lies much deeper. The proposals of Taylor attack some of the most cherished dogmas of ill-informed unionism. The timing of operations, and the selection of the fittest workman for special labour, two main characteristics in Taylor's method, are likely to find little favour, with those who urge the limitation of work as a precaution against unemployment, and the restriction of supply or of output as a weapon for enforcing the submission of employers. The selection of workmen according to ability or fitness defeats the aim of securing uniformity of wages to the skilful and the indifferent alike. Limited output works in a different way. There is no inducement to economy of exertion. If, for example, a rule of the trade compels a bricklayer not to set more than a definite number of bricks, per diem, it is useless to indicate methods and insist on a procedure that will shorten the operations, for already the more skilful have sufficient leisure.

Till the leaders of labour become more enlightened, and the present tendency is apparently to place direction in the hands of more noisy and less capable guides, there is little hope for the acceptance of the intelligent principles of economy of effort either as urged by Taylor and his disciples or the more scientific system on which physiologists are engaged. For Taylor must be regarded as a pioneer, an able and indefatigable pioneer, who saw his end clearly and bent all possible means to that end, but in proportion as these means were scanty so his system was incomplete. While admirably adapted for training the human instrument to work rapidly and economically, it takes no heed of the motive force. He did not consider sufficiently the power that worked the machine. The consumption of fuel, in this case the nutriment, the removal of waste products that clog operations, the effect of environment, the exhaustion of nervous centres, were all matters that lay outside his purview. Taylor was perfectly aware of his limitations; indeed he complained that he found nothing in the works of his predecessors that enabled him to estimate and compare the relative degrees of human fatigue. This volume of Professor Amar goes far to remove the complaint. For the physiological side of Taylorism is here investigated with a wealth of detail and illustration, that should prove most fruitful. The work is frankly addressed to the general public, and should be readily intelligible to those who are unfamiliar with the methods and processes of scientific inquiry.

It cannot be too clearly perceived and admitted, that the human machine is subject, so far as its motive force is concerned, to the same laws as inanimate motors. Its cells operate as innumerable silent furnaces, fuel and oxygen are necessary for its maintenance, the chemical energy of the nutriment provides both heat and work, the muscles actuate the limbs which produces effective work. For this reason, the author explains, in a series of preliminary chapters, the principal functions of the digestive and respiratory apparatus, and discusses the conditions of a rational activity. This introduction is necessary to enable the untrained reader to appreciate the difference between normal and pathological conditions, and to perceive how exercise in particular directions may favour or aggravate, predispositions that tend to promote, or injure health. The psycho-physiological relations are not omitted in considering the behaviour of the total mechanism, though here mechanical investigation ceases to be strictly informative. How emotions may in a greater or less degree modify the neuro-muscular energy escapes the investigator.

Not less necessary than the supply of energy in order to provide for the activity of the muscles and to ensure the working of the machine is the removal of the waste products due to cellular action. Fatigue is the result of the accumulation of these toxic products, and when the blood is no longer able to cope with its task of purification, the muscles function in a disorderly fashion and trouble ensues. Fatigue is described as fundamentally an intoxication, and is inevitably the consequence of exertion. It is even asserted that though the brain alone may have been working, fatigue will effect the muscular organs. There must, however, be great difficulty in tracing the connection between the brain and the muscular apparatus, for the operations of the brain are more than a little obscure. Notwithstanding all that has been done or attempted in cerebral localisation, no certain information of the localisation of the psychical faculties has resulted. We certainly read of one experiment, arranged to trace the effect of thought, but as explained, the conclusion seems hardly warranted. A subject was shut up in a calometric chamber and given the opportunity of studying mathematical physics, as presented in a heavy German treatise. The energy due to study, radiated in the form of heat was accurately measured, but the conclusion is not clearly drawn. A positive and, presumably, trustworthy result was obtained, for we are informed that a man who expends 2,400 calories per diem for his energetic maintenance, expends 9 or 10 calories more when his brain is active for 8 hours a day. While gratefully acknowledging the lucidity with which the mechanical appliances for measuring physical activities are described, and the excellence of the illustrations which demonstrate the fitness of those devices to the end in view, it must be admitted that the application of mechanical methods to analyse mental effort, and to discover the origin of thought is not equally successful. The mind remains withdrawn beyond the cycle of vital energies. The work done by the liberation of intellectual activity leaves no measurable traces in the form of heat or electricity. A suggestion is made, but whether by way of illustration or explanation is not quite clear, that some process analogous to radio-activity takes place in the cerebral cells, and that thought may be regarded as a radioactive phenomenon. This suggestion, for which not a particle of proof is offered, is not illuminating, for it is difficult to see how the principle of conservation of energy is maintained.

With far greater satisfaction, one turns to the more practical portion of the work to learn how the truths of physiological science, combined with acute observation and long experience, can be made available in the training of the normal and the rehabilitation of the maimed and broken. The problem is a vast one, and clumsy errors that are not easily detected may be far-reaching and irreparable. It is fatally easy to perpetuate an effete system whose evils are admitted, but whose remedy is delayed by the conflict of darkened counsels and a multitude of advisers. The haphazard system of apprenticeship is one of those institutions which are spared, not on account of its merits, but from the difficulty of replacing it by a better organised system. As it exists at present it is more than discredited, it is held to be pitiable and criminal. The disappearance of the professional guilds and corporations has removed a desirable atmosphere of industry and the permanent personal guidance and advice that were necessary to the training of the pupil. The increasing use of machinery and mechanical methods aggravate the evil by keeping the artisan entirely occupied with some elementary task, which forms but a part of the entire operation. The worker becomes familiar with only a fragment of a trade, and his mind is atrophied by constant repetition. Under the system of division of labour

carried to excess, it is impossible for a workman to grasp his craft as a whole. Advancement of technique, and the application of intelligence whereby improvements may be introduced and output increased, are hampered, if not rendered impossible. Are we to look for a radical or gradual improvement? Governments are generally sympathetic, and the industrial world is animated by a desire for agreement and action, but no determined severance from old paths is clearly indicated. Two circumstances suggest the need for a new departure: the innovation of female labour into the industrial market, and the necessity for finding employment for the partially incapacitated, an army of unfortunates that M. Amar estimates to amount to one-thirtieth of the European population. This is a staggering figure, but room must be made for these pathetic victims of internecine struggle. The author's contribution to the solution of the general problem would command respect at any time, but from his position, he may be assumed to represent very closely the views of official France. His authoritative utterances enable us to see the direction in which France is working, and supply the means of contrasting the methods and the outcome of the organisation that he directs with those that are made in this country, either by voluntary effort, or under Government auspices.

On the question of apprenticeship, the author regards its proper organisation as a task which should be undertaken by, and in, the trade school. There seems to have been hitherto a distinct, but unfortunate, line drawn between the literary education of the school and the technical instruction of the bench. Such a division is not necessary, the theoretical and the practical training might proceed *pari passu*. Two difficulties confront us at the outset: The provision of adequate teachers and the desire of an early pecuniary return on the part of both parents and pupils. The workshop teaching, as usually supplied, is inadequate. From worker to worker the chain is prolonged and closed, and not the smallest link of science is added to it. It is a vicious circle. A teacher, properly so-called, is continually receptive, his knowledge is enlarged from generation to generation, he plays his part in the progress of the world and his pupils profit by his enlarged horizon. Moreover, it must be remembered that the chance teaching of the workshops is as bad morally, as it is intellectually deficient. It too often perpetuates an unjust hatred of the employer and every one in authority who has the right to expect obedience. The atmosphere of mutual forbearance that now it is especially wise to foster, is not promoted by the indiscriminate mingling of workmen of all ages and grades. The trade school created *ad hoc* is an adequate remedy for the worst evils and a security against industrial chaos. Physiological examination would there select the apprentice according to his aptitudes and temperament, and direct his activity into those channels that would best contribute to national progress.

To many the most significant section of the book will be that which deals with the treatment of the crippled and disabled war victims. The methods of the physiological laboratory are thought to have here greater scope, and to be more applicable to the injured, whether sufferers from war or from industrial accidents, than to the able bodied. Without discussing this point, one reads with a sense of relief and gratitude, that there are trustworthy scientific grounds for believing, that 80 per cent. of the crippled and amputated are capable of being re-equipped and returned to the ranks of industry. Some 65 per cent. will take their place among their comrades, little handicapped by the treatment they have undergone, but the remainder will need specially-fitted workshops, which implies a difficulty in finding employment, owing to the reluctance of employers to meet the emergency. As far as possible, the aim is to fit the wounded to return to their original vocations, for evidently the loss of an experience, laboriously acquired and often of a lucrative nature, is most undesirable. Nevertheless reapprenticeship, the acquirement of a new trade, is occasionally a necessity, especially to those who have suffered the amputation of an arm. This necessity is faced heroically both by teachers and patients.

The provision of substitutes for amputated limbs, the ingenuity displayed in construction, the precautions taken to prevent pain and fatigue, the limitations imposed by the character of the amputation, are all treated impressively and prove most interesting. The devices and methods employed appeal to us both on humanitarian and professional grounds, but into details it is impossible to enter. In the case of amputation the object, of course, is to fit upon the stump an appliance to replace the amputated segment, in a manner that can be mechanically controlled by the muscular force still available. The attachment must be strong, but it must not impede the movements involved, or those of other articulations; it must be adapted in respect of weight and dimensions to the strength of the stump, and in the case of the upper limbs, an organ of prehension must be provided in a form that admits of protracted and varied employment. Bearing these principles and requirements in mind, the author explains the whole operation of fitting legs and arms, and hands to the mutilated, pointing out the assistance that mechanical examination can render from the physiological side, and the modifications that are needed to meet the special conditions to which the subject will be submitted.

The degree of success that has been attained in France, and presumably elsewhere, is most encouraging. The provision of an arm presents greater difficulties than the assembling of a leg, and for a long time the prospect of making a one-armed man able to work, seemed sufficiently remote. Yet it is now possible to enable those who have suffered the disarticulation of an arm, or the amputation of both arms, to take hold of objects with the artificial arms provided, and to perform the little actions of everyday life. The hand, with the mechanism for moving articulated fingers, weighs only 7 ounces, and the whole arm complete never weighs more than 40 ounces. Yet the efficiency is such, that it enables the wearer "to hold a weight of 15 lb. to 18 lb. between the flexed fingers and the opposing thumb, to pick up with the finger tips a pin, or a match, to button his clothes, to write, to turn over the leaves of a book . . . we have known the wearer of such arms to operate with sufficient dexterity the keys of a typewriter, or the keys of a piano, and even the bow of a violin."

If the mechanical treatment is satisfactory the ultimate object is at once elevating and dignified. The suggestion of charitable relief is banished and a spirit of independence and self-reliance is encouraged. An education is given which regulates the efforts of the patient, disciplines his movements, and adapts them to exact operations by himself, being spared all superfluous fatigue, and waste of time and energy. It is regarded as an indispensable condition of this education, that the refitted soldier must be sent into active life unfettered, and capable of managing his own affairs, to work in shop or factory or on the land, unsubjected to the slightest constraint, and requiring no undue favour. A principal and praiseworthy aim is so to prepare the wounded soldier for his calling that his position shall be secure and he may escape the hazards and the degradation of charitable employment. M. Amar has produced a work whose study cannot but reward all those who are earnest in promoting the welfare of the disabled, and improving the lot of those who have heard the call of their country to defend the right.

BOOKS RECEIVED.

Can We Compete? Germany's Asset in Finance, Trade Education, Consular Training, &c., and a Proposed British War-Cost Reduction Programme. By G. E. MAPPIN. London: Skeffington and Son, Limited. [Price 4s. 6d. net.]

The Natural Organic Colouring Matters. By ARTHUR GEORGE PERKIN, F.R.S., F.I.C., and ARTHUR ERNEST EVEREST, D.Sc., Ph.D., F.I.C. London: Longmans, Green and Co. [Price 28s. net.]

The Physiology of Industrial Organisation and the Re-Employment of the Disabled. By Professor JULES AMAR. Translated by BERNARD MIALL. Edited, with Notes and an Introduction by Professor A. F. STANLEY KENT, M.A., D.Sc. Oxon. London: The Library Press, Limited. [Price 30s. net.]

The Payment of Wages: A Study in Payment by Results under the Wage System. By G. D. H. COLE. Trade Union Series, No. 5. London: George Allen and Unwin, Limited. [Price 6s.]

NEW YEAR HONOURS.

THE list of honours conferred by His Majesty on New Year's Day does not include the list usually prepared by the Prime Minister, which is temporarily postponed, but as his list is ordinarily political we have here little interest in it. The honours actually conferred are those earned by direct service in connection with one or other departments of the State, and, naturally, the list includes a large number of engineers. In the Civil Service List the Right Hon. Sir Eric Geddes is promoted from K.C.B. to G.C.B. in the Civil Division. Already he has the Grand Cross of the Order of the British Empire. Mr. Robert Elliott-Cooper, Chairman of the War Office Committee of Hutted Camps, is made a Knight Commander of the Order of the Bath in the Civil List.

In the Colonial Office List, Mr. James Fraser, M.Inst.C.E., Chief Commissioner for Railways and Tramways in New South Wales, has been appointed a Companion of the Order of St. Michael and St. George, while in the India List Mr. Henry Hubert Hayden, C.I.E., D.Sc., Director of the Geological Survey of India, has gained the distinction of C.S.I. for meritorious services during the war. Mr. Bernard D'Olier Darley, Executive Engineer, Tarai, U.P.; Mr. Francis John Preston, Chief Engineer, Great Indian Peninsula Railway, Bombay, and Mr. Frederick William Hanson, late General Traffic Manager, Bombay, Baroda and Central India Railway, have each received the distinction of C.I.E.

In the Navy List the following honours have been bestowed: C.B. (Military Division) upon Engineer-Captain Edward John Weeks, R.N.; C.B. (Civil Division) upon Engineer Rear-Admirals William George Mogg and George William Hudson, and Engineer-Captain John H. Jenkin, R.N. A Knight Companionship of the Order of St. Michael and St. George has been conferred upon Rear-Admiral Henry Humphreys, C.B., while a C.M.G. has been bestowed upon Engineer-Captain Sydney Rider, R.N., and Engineer-Commanders Richard Barns Morison, R.N., Horace George Summerford, R.N., and Arthur Edward Hyne, R.N.

In connection with the Order of the British Empire, a Military Division has now been established in addition to the Civil Division, under which so many appointments have been made. In this Military Division the following gentlemen have received the distinction of Commanders (C.B.E.): Engineer-Captains H. W. Metcalfe, R.N.; G. W. Murray, R.N.; and G. W. Roome, R.N. The following have been made Officers of the Order (O.B.E.): Engineer Lieutenant-Commander H. C. Anstey, R.N.; Engineer-Lieutenant J. R. Buchan, R.N.; Engineer-Commander J. S. Constable, R.N.; Engineer-Commander H. E. Dowling, R.N.; Engineer-Commanders J. R. Farish, B. F. Freeman, R.N., and A. Gillespie, R.N.R.; Hon. Engineer-Commander W. A. Graham, R.N.R.; Engineer Lieutenant-Commander F. G. Haynes, R.D., R.N.R.; Engineer-Commanders E. O. Hefford, R.N.; J. Kelly, R.N.; A. E. Lester, D.S.O., R.N.; A. G. Liston, R.N.R.; and Engineer-Commander A. J. C. Moore, R.N.; Engineer Lieutenant-Commander L. M. Morris, R.N.; Engineer-Lieutenant C. H. L. Pilditch, R.N.; Engineer-Commanders T. P. Pover, R.N.R., and F. J. Roskruge, D.S.O., R.N.; Engineer-Lieutenants J. Sandieson and J. A. Seabrook; Engr.-Commander J. C. Talbot; and Engineer-Commander C. J. M. Wallace, R.N. A Membership of the Order (M.B.E.) has been conferred upon 1st Engineer F. Ablett.

POTASSIUM CHLORIDE.—In order to separate potassium chloride from the crude solution which, as a rule, contains much sodium chloride, the crude salt should, according to Krull (*Kali*, 1917, pages 307 to 316), be extracted at about 100 deg. C. (90 deg. to 130 deg.) and the solution then be cooled to 15 deg. or 25 deg. C. In the extraction low-pressure exhaust steam is utilised. To obtain well defined crystals the cooling can not as a rule be carried out in ways which admit of the recovery of the heat. The remaining liquor is re-utilised in the further extraction and should for this purpose be freed of sulphates.

OPENINGS FOR INDUSTRIES IN SOUTH AFRICA.—The recent expansion of industrial activities in the Union of South Africa has, amongst other results, induced certain municipalities and similar public bodies to offer specially favourable terms to manufacturers in the way of water and power rates as well as sites for the establishment of industries. The Trade Commissioner for the Union has been notified that the Pietermaritzburg Corporation is prepared to offer suitable sites on very reasonable terms, and to submit plans with additional information as to supply of labour, raw materials, railway communications, &c. The water rate varies from 1s. 6d. per 1,000 gallons for a monthly consumption of 250,000 gallons, to 9d. per 1,000 gallons up to 12,000,000 gallons. Electricity can be supplied on a graduated basis of from 3d. to 0·84d. per unit and for industries of a kind not already established a reduction will be made of 33·3 per cent. off these charges.

HOME AND EXPORT PRICES OF IRON AND STEEL.

THE Minister of Munitions gives notice of the under-noted information in supplement of the notices which have already appeared with regard to home and export prices of iron and steel (see ENGINEERING, vol. cvi, page 646):—

1. The export prices in Schedules EX/2 and EX/3 are for net cash against documents, and are not intended to include any provision for extended credit. In the event of credit being given, additions may be made to the prices to cover the credit at a reasonable rate of interest.

2. The following alterations are to be made in the export prices of iron and steel (Schedule EX/2), to operate as from January 1, 1919:—

The sixth line of prices will read as follows:

	Per Ton. £	s.	d.
Small angles, tees, flats, channels and joists	18	10	0

The seventh line will read as follows:

Joists 6 × 3 and upwards ... ... (Joists under 6 × 3 are subject to the same prices and extras as channels of a similar size.)	16	2	6

The ninth line of prices will read asfollows:

Small rounds, squares and hexagons	18	10	0

The following additions are to be made to List EX/2:

	Per Ton. £	s.	d.
Steel-plate cuttings, suitable for re-rolling...	13	10	0
Rails, hollow bridge, 45 lb. per yard and over	17	0	0
Rails, second-hand, all sections ...	13	0	0
Sheet bars and tin-plate bars	12	17	0
Iron puddled bars	15	15	0

The extra of 3*d.* per ton allowed to be charged by stock-holders over the maximum prices for home delivery applies equally to sales for export.

3. The export prices on Schedule EX/2 for rails under 45 lb. per yard relate to flat bottom, double head, bull head and bridge rails. The prices for rails exceeding 45 lb. per yard relate to flat bottom, double head and bull head sections. The price for bridge rails, 45 lb. per yard and over, has now been fixed at 17*l.* per ton (as above).

4. *Export Drawbacks.*—Export drawbacks on iron and steel are only applicable to those classes or descriptions of material for which export prices have been or will be fixed. Export prices will not be fixed for manufactured goods, nor for descriptions of iron or steel, the prices of which for home delivery are not controlled.

5. *Home Prices.*—The column of prices on the first page of Schedule SH/1 should be headed "Maximum Prices." The column of prices on the second page of this schedule should be headed "Maximum Prices" instead of "Fixed Prices."

6. *Bar Iron.*—The price of bar iron for home sales will be advanced to 15*l.* 10*s.* per ton f.o.t. makers' works, from January 1, 1919.

7. *Marked Bars.*—The price of marked bars for home sales will also be advanced from January 1, 1919, to 18*l.* per ton f.o.t. makers' works.

8. *Tin Plates and Steel Sheets.*—Arrangements have been made with manufacturers of tin plates and of steel sheets less than ¼ in. thick, under which the equivalent of the subsidies now being paid by the Ministry on this material will be refunded. The Maximum Price Order relating to tin plates will therefore be amended, and particulars of the increased prices will be published immediately. The maximum prices of steel sheets less than ¼ in. thick have now been abolished.

"COAL SAVING BY SCIENTIFIC CONTROL OF STEAM BOILERS."

TO THE EDITOR OF ENGINEERING.

SIR,—Two totally different methods are available for saving coal in boiler plants. One is the method of the chemist, applying to boiler plants designed for manual firing and cleaning of furnaces, scientific superintendence and laboratory methods for controlling manual labour, involving incessant vigilance by a well-paid chemical expert. The other is the method of the engineer, which is open to any chemical or scientific check by experts, but which eliminates the variable and uncertain factor of manual methods, and assures scientific accuracy of combustion by adopting positive mechanical methods of continuous automatic firing and cleaning of furnaces, mechanically supplied with coal, and boiler plant of the utmost simplicity, of correct modern design.

All that is really needed for boiler-plant efficiency is complete combustion at high temperature, viz., very hot fires, and no avoidable heat loss in riddlings or in unburnt fuel in the ash. In other words, the coal must be burnt to a clinker, and a pure white heat must be constantly maintained. In low-set cylindrical boilers designed for hand-firing, it is barely possible to observe the fires accurately; both firing and cleaning operations being manual and intermittent, it is extremely difficult to maintain high efficiency, although with good, clean coal and a highly expert and willing staff, high efficiency is possible.

In modern steam plants eliminating manual labour by positive mechanical methods, both wages and fuel costs are minimised, and an intense white heat of combustion can be maintained. That this is so is shown by the enclosed photograph, taken at the Hull Corporation Electricity Works, from a single-furnace under a high-set water-tube boiler, this furnace being fitted with an Erith-Riley continuous-cleaning stoker, and burning hourly 2 tons of low-grade coal containing 24½ per cent. ash and having a heating value of 9,453 British thermal units per pound. This coal is burnt to a clinker. With this splendid combustion, the boiler efficiency is so high that the available waste heat in exit gases does not justify the cost and upkeep of an economiser or other waste-heat appliance, so the gases have free outflow to the chimney. Oil-free exhausts from auxiliary turbines impart their total heat to the feed-water in an efficient heater, and by thus returning the latent heat to the feed-water, their working cost is merely nominal.

The coal is supplied by a self-filling grab hoist and transporter to high-level hoppers supplying the continuous-cleaning stokers, and the ash is continuously discharged and removed by wagons on the floor below the boilers. Manual labour is thus eliminated by positive mechanical methods in a correctly-designed boiler plant, while the high-temperature complete combustion assures minimum coal costs.

The Erith-Riley stoker, is composed of any number of self-cleaning retort units, so that the identical thermal efficiency and the identical elimination of manual labour is assured on all makes and all sizes of water-tube boilers. It is thus just as easy for the industrial plant burning 2 tons of coal hourly, to have two boiler units each burning 1 ton per hour, as it is for the huge electric power station developing 25,000 kw., corresponding to 300,000 lb. steam hourly, to have a series of large-unit boilers with the identical methods.

In recent articles in ENGINEERING by Mr. Brownlie, investigations on 250 steam plants were reported, nearly all using cylindrical boilers arranged for hand-firing and hand-cleaning of fires, and mostly having economisers. Day-load tests under working conditions showed very defective combustion, which was confirmed by the enormous quantity of heat which the boilers failed to absorb; in one case the economiser received enough waste heat for it to make 19 per cent. coal saving; while the average coal saving by this waste-heat appliance for 155 plants was 11·4 per cent. Including economisers, the thermal efficiency on test was 60 per cent.; while the yearly coal bill averaged 2,166 tons per boiler, viz., 8,664 tons coal for the average plant with four such boilers, which would need four men per shift.

The best result practicable with incessant supervision of manual firing and cleaning in such plants would be 75 per cent., viz., 1,733 tons coal saved yearly in the average four-boiler plant, actually working at 60 per cent. efficiency. The cost for skilled superintendence by a trained chemist would naturally absorb the bulk of the value of the 1,733 tons coal which he would hope to save, even assuming that the firemen were willing to carry out his instructions fully, without any extra pay. It seems evident that so long as boiler plants designed for manual firing and manual cleaning are retained, there is very small inducement to pay for such skilled superintendence of labour, merely for the prospect of saving coal, but with the certainty of increased wages bills. The engineer's method, on the other hand, eliminating the variable feature of manual labour, and substituting mechanical appliances and boiler plant of correct modern design, is rapidly becoming universal, and similar labour and coal saving methods are now available for new steamships, with mechanical coal-handling appliances adapted for the rolling and pitching motions of vessels.

I am, yours truly,

CHARLES ERITH.

70, Gracechurch-street, London, E.C. 3,
December 30, 1918.

"TESTIMONIALS."

TO THE EDITOR OF ENGINEERING.

SIR,—I would like to draw your attention to the out-of-date iniquity which is the established custom of employment in England in the world of civil engineering, and, I believe, in most of the professions.

I am an Associate Member of the Institution of Civil Engineers, and have worked for some six years at my profession under fairly prominent engineers before I went to Canada and obtained as good testimonials as I could want from each in turn, so that my objection cannot be attributed to personal grievances.

I went to Canada with a sheaf of them neatly typed and pinned together, and started in to find a job. I had about three letters of introduction and used them—unnecessarily I am now convinced—to be able to state my case. I conscientiously deposited a full set of testimonials with each engineer I interviewed, and am quite satisfied that if they were ever looked at at all, it was only out of curiosity; they were never asked for, and are never required to obtain a berth. A five-minutes' talk is all that an employer wants with an applicant to decide if he fills the bill or does not. The art of "sizing a man up" is highly cultivated in the Dominion.

I have lived and worked in Canada at my profession for ten years before war brought me over here, and I thought before returning in the course of demobilization I would try if I could get a billet in England, as my business is all broken up in the past four years, and I have to begin over again somewhere.

I applied to the Institution for information as to the direction in which I should apply, and was very courteously told that I was too early, but would I fill in, if I so wished, the enclosed form of particulars of experience, &c. On the back of this form is the legend "The accompanying application by Mr..... is hereby approved.

"(Signature of present employer)....."

Now, why must my application for a new job be approved by my present employer. If I have not suited, or suited too well, one man, why must I be placed under his power as to another job.

This is the tyranny to which I take exception. I would rather go on a prairie farm than re-enter the servitude of employment in my profession which I see still exists in England.

I shall return to Canada, where a man can be free, and call his soul his own, even if he does serve another for a salary.

Yours, &c.,

G. H. PETHICK, Capt.

1st Batt. Canadian Railway Troops,
France, December 17, 1918.

DRAUGHTSMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—It has been a pleasure these last few weeks to read through your advertisement columns and note the gradual elimination of a phrase which had begun to stink in the nostrils of all draughtsmen: "Apply to your nearest Employment Exchange"—and one wonders if ever the Government will realise what a colossal blunder it made when it gave the employer a leasehold on his draughtsmen's services.

At the very time when the Government ought to have been getting the best efficiency out of every draughtsman in the country—and draughtsmen are key-men—they were in very many cases getting the worst, or none at all by reason of allowing—nay, assisting—the employers to keep their men in cold-storage against the time when they would be required for commercial work once more.

Take my own, which is a typical case. For the last three years my work has consisted almost entirely of tracing and making copies of sketches, &c., work obviously not worth 30*s.* per week; yet my firm—or more correctly speaking, the Government *through* the firm—has been paying me 4*l.* per week for this work. They didn't mind; if the money was not paid to me, it would accrue to the Government in the form of excess profits, meanwhile no rival firm has been allowed to engage me, although your advertisement columns have week by week shown the great need for experienced draughtsmen for work of national importance. In short, the Government has for three years paid me for doing practically nothing, which is perhaps, after all, a not very unusual thing for a Government to do.

There are other cases in which the D.O.R.A. has been used as a means for keeping down wages. I know of a draughtsman who hasn't had a rise of wages for over six years. Shortly before the war, he applied for a rise, and was told—nay, asked—with many blandishments and much rubbing of hands, to "leave the matter over for a few weeks, we'll see you right," &c., &c. Shortly after the commencement of the war, he renewed his application, but his firm were now on Government work, and the "leaving certificate" was in full swing. No pretty speeches this time, no rubbing of hands or jocular remarks; he was bluntly told, "No," he "wasn't giving satisfaction," but all the same he was shortly afterwards *refused a leaving certificate.*

I know of another case where the drawing office is in a most insanitary condition and infested with vermin. Periodically, an abominable stench makes itself manifest, and after due search, a dead and half-decomposed rat is hauled out from some filthy corner. It is safe to say that the majority of the men would have left on this account alone, but for the D.O.R.A., which decrees that they could only leave by permission of the management.

In fairness to the said management, let me hasten to add that since becoming Government controlled the office floor has been washed on quite a number of occasions, also a coat of paint has been laid—over the dirt—on what, in pre-historic days, must have been wainscotting.

Liverpool, December 22, 1918. "VASSAL."

WOOLWICH ARSENAL.

TO THE EDITOR OF ENGINEERING.

SIR,—It has been my privilege and pleasure, to superintend the manufacture of an enormous amount of war work in the engineering workshops of a large company in the North of England, and in this sense, have been associated with Woolwich Arsenal throughout the whole period of the war, and I freely endorse the communication from your correspondent "D."

In this connection, the range of my experience covers a wide field, and, whenever I wanted information, personally sought, or through my representatives, it was freely given, and of great value. The managers I had to deal with accepted innovations when suggested. Their representative freely visited our works. Also, my impression is, that apart from ordinary routine work, Woolwich has been called upon to carry out an enormous amount of experimental work, make the number one of many speculative fighting machines, prepare the way, and on the whole, the managers at Woolwich deserve well of their country.

Yours faithfully,

December 23, 1918. "H."

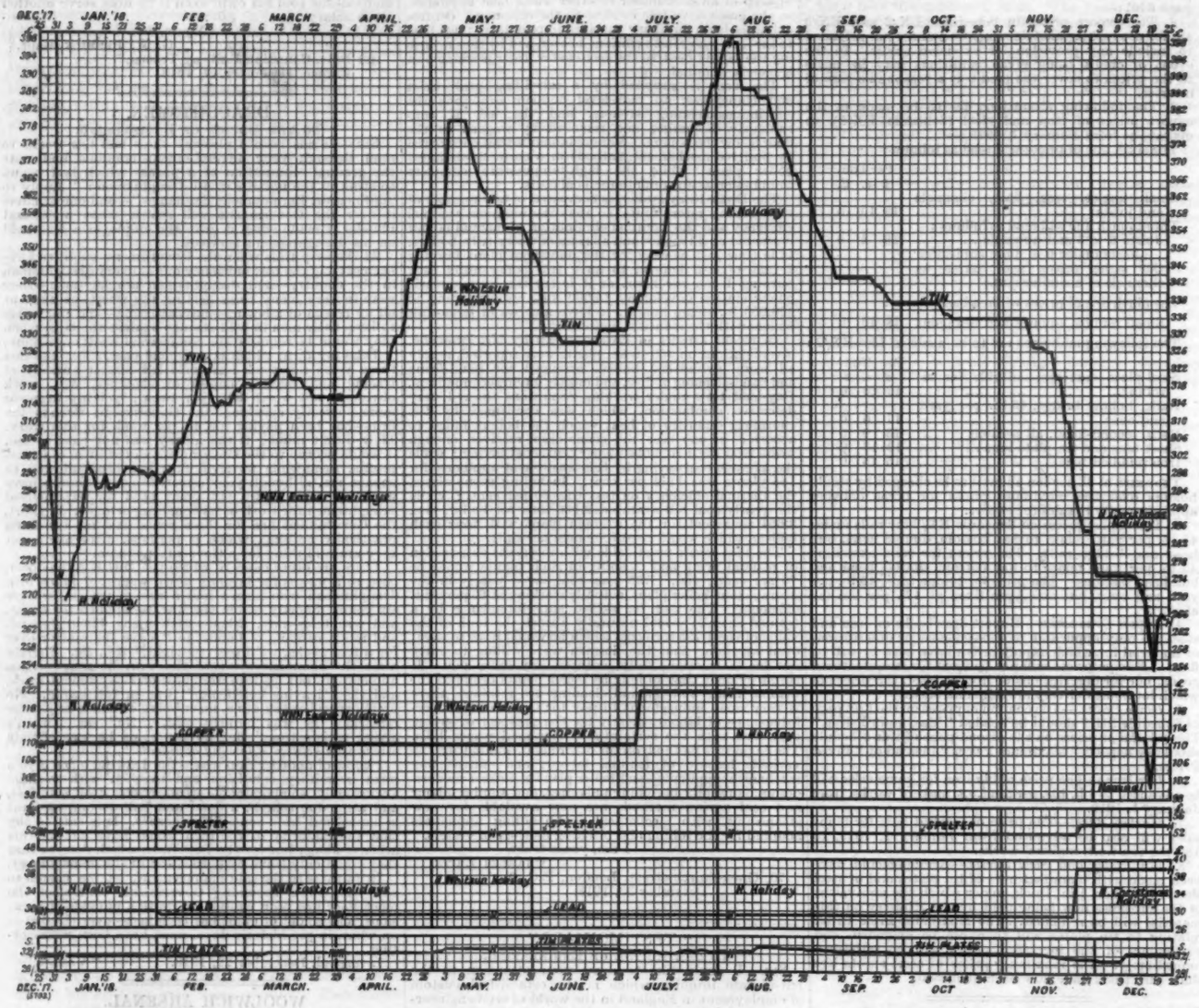
OUR INDUSTRIAL MENACE.

TO THE EDITOR OF ENGINEERING.

SIR,—For the past year or more our patriotic journals have been warning the Government against unpreparedness for the economic war which many people believe will follow the signing of the peace terms. Although the average Englishman can be relied upon to refrain from patronising firms who attempt to deal directly with goods of enemy origin, there is danger that the difficulty will be overcome by the enemy sending his goods through neutral countries and particularly to

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagram above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal, and the prices for all metals are per ton. The price of tin plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents two market days, and the horizontal lines represent 2*l.* each, except in the case of tin plates where they represent 2*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig-iron was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship plates were priced at 11*l.* 10*s.* and heavy rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For these official regulations, see page 45, vol. cii.) The prices for iron and steel for export have also been controlled, but a new series of regulations and prices have been issued and appear on page 646 of our issue of December 6 last and on page 23 of this issue. The Minister of Munitions had also issued certain regulations controlling the prices and dealings in non-ferrous metals; these restrictions were removed on December 17, 1918.

Sweden and Holland, where he is sure to receive the help that he needs.

Sweden has been particularly friendly to the Huns and hostile to the Allies from the commencement of hostilities, and if strict justice were done, the Allies would have every reason for boycotting those countries that have been supporting the Germans in their infamous campaign against the liberties of the world. Nothing, however, has yet been done by our own Government to prevent the importation of goods coming from these countries nor to protect those industries which have grown up during the war from unfair competition.

Ours is a case in point. We were induced to take up the manufacture of certain articles which, prior to the war, were practically Swedish and German monopolies. Our markets were formerly flooded with certain types of oil lamps and heaters made in those countries, to such a degree that when the war started there was not one firm in this country in a position to supply the wants of the various war departments. Several firms, including ourselves, placed their works at the disposal of the Government, and have maintained a steady supply of these goods. No doubt most of such firms expected that they would be supported by the Government so far as the future demand for these articles is concerned, in order that we may not again be placed in the position of having to depend upon foreign countries for such supplies.

It may astonish your readers to know that already these goods are pouring into the country from Sweden as in pre-war times, and if these importations are allowed to continue, it is more than likely that British firms who have gone to the trouble and expense of adapting their works to their manufacture may be compelled to close down.

We feel assured that it is not the wish of the great majority of the British public that this should be so. It is merely another illustration of the indifference of the Government of this country to the real industrial welfare of the nation.

Whether the same treatment is to be meted out to firms in other lines of business remains to be seen, but it appears to us certain that unless a vigorous protest is made by the manufacturers throughout the United Kingdom, we shall find ourselves once more subjected to the same system of peaceful penetration by the Germans and their so-called "neutral" friends—a system which, according to Professor Hauser, in his great work entitled "Germany's Commercial Grip on the World," would have placed the wealth of the world in the hands of the German people within the next twenty years had they been content to persevere along these lines instead of outraging public opinion by starting their military adventure.

Yours faithfully,

THE KITSON-EMPIRE LIGHTING COMPANY, LIMITED.
(ARTHUR KITSON, Managing Director).

Stamford, Lincs., December 30, 1918.

TOSI DIESEL ENGINES.

WE have recently published on several occasions information indicating the rapid extension which is being made in Allied and neutral countries in the internal-combustion engine industry, especially where marine work is concerned, and in this respect the part being played by our Italian Allies is in keeping with their past record of substantial performance in the development of this type of prime mover.

The subject of the present article is the Diesel engine developed by Messrs. Franco Tosi, of Legnano, Milan. In ENGINEERING of May 24, 1912, the then current types of Tosi Diesel engines were fully illustrated and described, and a comparison between the illustrations and particulars then given and those of the engines now to be dealt with will give a clear idea of the progress made in the interval and the trend of the present practice of the firm.

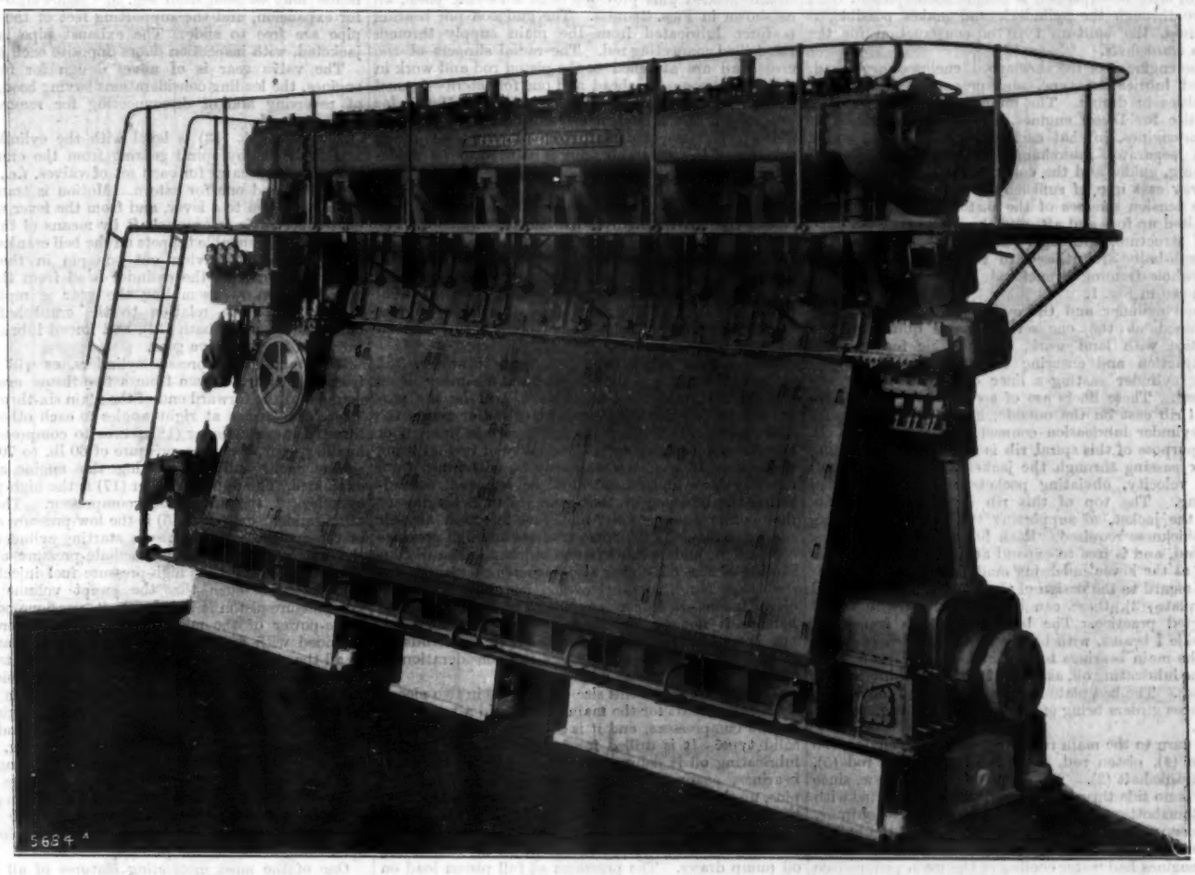


FIG. 1. SIX-CYLINDER FOUR-CYCLE DIESEL ENGINE, BY MESSRS. FRANCO TOSI, LEGNANO, MILAN.

Messrs. Franco Tosi have already built over 400 Diesel engines, these being of both the two-stroke cycle and four-stroke cycle types, totalling, in 1,200 cylinders, about 120,000 b.h.p. The range of horse-power developed hitherto per cylinder is from 15 b.h.p. to 400 b.h.p., and the average power per cylinder being 100 b.h.p., a high average, be it emphasised, considering that the engines comprise besides those used for land power generating stations, pumping sets, marine engines for cargo vessels, submarines, and many for auxiliary service on board ship. The two-cycle engines were built chiefly for the higher powers, i.e., over 200 b.h.p. per cylinder. The speeds of revolution range from 110 r.p.m. to 120 r.p.m. for land engines, to 400 r.p.m. for submarine and high-speed engines. Of marine engines alone Messrs. Franco Tosi have built, or have under construction, 50 engines, totalling 25,000 b.h.p., the largest size hitherto being a six-cylinder unit of 2,400 b.h.p. and the smallest 150 b.h.p.

As described in ENGINEERING of June 28 last, Messrs. Franco Tosi have decided to concentrate on the four-stroke cycle engine in the future, for they are of opinion that if the same life is to be obtained from the two-stroke cycle type as from its rival, any advantage of reduced space and weight which it may possess disappears. Advocates of the two-stroke cycle engine give, as one of the principal reasons in favour of this type of engine, the greater power that can be developed in a given size of cylinder, but Messrs. Franco Tosi point out that this advantage is only obtainable at the expense of the greatly increased temperature of the cylinder, piston heads, &c., which arises from the combustion of the larger quantity of fuel necessary for the increased power per cylinder. The ratio of increase in consumption of fuel per cylinder of equal size is, in fact, greater than the ratio of increase of the power obtained from the cylinder, the consumption of fuel per horse-power hour being somewhat greater in the two-cycle than in the four-cycle engine. This greater quantity of heat developed in each cylinder in a given time and the resulting higher temperature is confirmed by the colour of the surfaces of the parts exposed to it, and is responsible for the troubles that have been experienced in the two-stroke engine.

It follows, therefore, that the two-stroke cycle engine, if designed with the same size of cylinder, will have a shorter life and may require more frequent overhauling than an engine of the four-cycle type. This is a fact of great importance not only with heavy oil engines for cargo boat propulsion which must run uninterruptedly at long periods at full load, but also for the lighter type of engine used for submarines, which, although not required to run fully loaded for such long periods, are subjected to high stresses. Considerable progress has doubtless been made with the two-cycle engine, and many improvements introduced into the design, material, cooling of the cylinder and piston, to overcome the difficulties experienced. The modern two-cycle engine is thus undoubtedly more reliable than the older types, but such engines have been in service for too short a time for a definite judgment on them to be arrived at. On the other hand rapid progress has also been made in the design of the four-stroke cycle engine, whilst many years of highly satisfactory service at full load have already been recorded. Regarded in another way, if an equal life is required from both types of engine—which is what is called for in both land and marine service—an equal quantity of fuel should in both types be consumed in a cylinder of a given size in order to secure equal temperatures. If this condition is adhered to the result will be that the same power will be developed by both types with an approximately equal weight and space.

The crosshead type of construction has been adopted by Messrs. Tosi for all slow-running engines, both for marine and land work, in lieu of the trunk piston design. The chief advantages of the trunk piston engine are simplicity, lightness and compactness. The piston, however, with this type is required to perform the double function—firstly, of maintaining airtightness between the high pressure of compression and combustion on the one side and the crank chamber at approximately atmospheric pressure on the other (i.e., the piston is an obturator); and, secondly, of a crosshead in taking the side thrust consequent upon the angularity of the connecting rod. The reliability of its performance in this dual rôle, unless with special attention, is not all that can be desired. When the rings lose their elasticity due to continued exposure to high temperature, or become gummed up, gases leak past the piston ring, and heat up the working surfaces of the piston with the possible result of piston seizure.

The proximity of the gudgeon pin bearing to the hot piston crown tends, also, to overheat this bearing, giving rise in turn to the danger of distortion and seizing of the main piston. Further, leakage of burnt oil past the piston rings contaminates the crank chamber lubricating oil, causing a more speedy reduction in its lubricating qualities than would arise by normal use. The consumption of lubricating oil, also, is high, due to the oil which is splashed on to the cylinder walls finding its way into the combustion chamber and so out through the exhaust.

In the present article we propose to deal with the standard Tosi slow-speed four-stroke cycle engine, now being constructed for land and marine work, of various sizes of cylinder units, three, four, six and eight units going to make up the complete engine, according to the power required. Fig. 1, on the present page, is a reproduction of a photograph of a six-cylinder Tosi engine of the four-cycle type; but for a detailed description reference will be made to Figs. 2 to 5, on page 27. Of these views, Fig. 2 is a longitudinal combined elevation and section, while Figs. 3 and 4 are two cross-sections, one through a main cylinder and one through the compressor. Fig. 5 is a section, to a larger scale, through a main cylinder head, showing the inlet and exhaust valves.

As already stated, the engine is of the four-cycle type

and the six cylinders are approximately 17 in. diameter by 26 in. stroke, developing 83·5 brake horse-power per cylinder, or 500 brake horse-power total in the six cylinders at 180 r.p.m. The piston speed at full speed of revolution is 780 ft. per minute, and at full power the corresponding mean effective pressure is 62·5 lb. per square inch. With a mechanical efficiency of 78 to 80 per cent. this gives an indicated mean pressure of about 80 lb. per square inch, which is a moderate figure, allowing a very desirable margin for contingencies and making possible the development of the 500 b.h.p. well within the capacity of the engine at a lesser speed of revolution than the designed figure of 180. We hope to publish at an early date the result of trials at sea of engines of this type. The piston speed is also moderate. The stroke/bore ratio of 1·55 gives ample room for the accommodation of the valves in the cylinder head, keeps the height of the engine within reasonable dimensions (dismantling as will later be explained is largely accomplished from above through the cylinder), and makes possible, if required, the built-up type of construction for the main crankshaft.

The engine is of the slow-speed, enclosed, crosshead, forced lubrication type, and presents a number of novelties in design. The main framing follows land practice for Diesel engines, and marine practice for steam engines, in that each cylinder with its framing is a separate, interchangeable unit. The jacket, framing, guides and the columns are cast in one piece of grey cast iron of sufficient scantlings to carry the main tension stresses of the piston load. Each unit is bolted up fore and aft, and the whole makes a most rigid structure, although somewhat heavy, since no through-bolts are utilised to take the tension load. The whole framing is enclosed by light metal doors, as shown in Fig. 1.

Each cylinder and the cylindrical guide faces are machined at the one setting, as is quite common practice with land work, this making for speed of construction and ensuring concentricity. Into each outer cylinder casting a liner of special cast iron is pressed. These liners are of special design, having a spiral rib cast on the outside, in which the bosses for the cylinder lubrication connections are incorporated. The purpose of this spiral rib is to give to the cooling water passing through the jacket a definite path and high velocity, obviating pockets and ensuring equal cooling. The top of this rib is machined and fits into the jacket, so supporting the liner and reducing the thickness required. Each liner is anchored at the top end, and is free to expand at the lower, the water joint at the lower end being made in the usual way.

In regard to the design of the cast iron framing and bed plate (3), these can be said generally to follow accepted practice. The bed plate (3) is framed of two side I beams, with box section cross girders carrying the main bearings totally enclosed to form a sump for the lubricating oil, as is usual with forced lubricating engines. The bed plate is not supported at the centre, the cross girders being of ample section to transmit the loads.

To turn to the main running parts of the engine, the piston (4), piston rod, crosshead, connecting rod (5), and crankshaft (2). The piston is quite shallow, since there is no side thrust to be carried and it is fitted with ten Ramsbottom cast iron rings to ensure gas tightness. It is connected to a flange on the top end of the hollow piston rod, and is designed for oil cooling. Earlier Tosi engines had water cooling of the main pistons (see ENGINEERING, July 24, 1912), but oil cooling with this special design of piston is now standardised. In the piston crown is a spiral passage for the cooling oil, which is delivered to the centre of the piston crown—the hottest part—through a central pipe in the hollow piston rod, then spirals round the crown and discharges out of the piston crown down the outside of this hollow pipe and so to the crankchamber. It is claimed for this method that the efficiency of cooling is exceptionally high, and so, in spite of the low specific heat of lubricating oil as compared with water, satisfactory results are achieved, and the risk of carbonisation of the oil is very much reduced. The objection to water cooling is the danger of leakages of water contaminating the lubricating oil with most disastrous results to the main bearing surfaces. A very small quantity of water mixing with lubricating oil greatly reduces its lubricating efficiency.

On the other hand, lubricating oil is a high priced commodity, and with all Diesel engines the consumption is relatively high, especially in comparison with turbine machinery. Using lubricating oil for the purpose of cooling the pistons tends to lessen the useful life of the oil, and if the supply to the piston crowns should be intermittent carbonisation rapidly takes place.

The crosshead adopted on all Tosi engines is of unusual design. With all other designs of Diesel engines the type used has two top end bearings, the gudgeon pin being fixed to the piston rod. With Tosi engines the gudgeon pin is fixed in the connecting rod, and the single bearing is in the piston rod. With this type great care has to be exercised in the design of the connecting rod to ensure a sufficient section of the fork to allow for the bending moment consequent upon the piston load, and especially is this the case with a connecting rod drilled for forced lubrication.

The connecting rod of the engine illustrated is relatively short, being 3·8 cranks, and to minimise the side thrust on the guides the centre line of the cylinder is set slightly out of line with the centre of the crank shaft, as will be seen on reference to Fig. 3. The unique feature of the Tosi cross-head, however, is the gudgeon pin, which, as usual with a single top end bearing, is pressed into the eyes of the forked connecting rod. Outside the gudgeon pin a sleeve is keyed on. The outside of this sleeve forms the bearing surface, and around this sleeve are the usual bearing bushes let into the end of the piston rod. Adjustment for wear is made by the square-headed pins provided with a locking plate, all as shown in Figs. 2 and 3. The gudgeon pin bearing is force lubricated from the main supply through the drilled connecting rod. The radial slippers of the crosshead are attached to the piston rod and work in the guides—one for ahead and one for astern—formed in the framing as already described. Means for adjustment of the slippers or guides are provided.

With the type of construction adopted the working pressure of the top end bearing is reduced to the moderate figure for forced lubrication of 1,600 lb. per square inch without an unduly long pin being necessary, so minimising the bending moment for which the forked end of the connecting rod has to be designed. The overall dimensions of the crosshead and slippers are such that, with the bottom end disconnected, the piston rod, crosshead and connecting rod can be withdrawn with suitable tackle through the cylinder. The usual method of dismantling these parts with Diesel engines is to withdraw from below as has often been described in these pages.

Access from below to adjust main bearings, &c., is provided through the large crank chamber doors (see Fig. 1). The chief concern will be the procedure to be adopted in order to clean or renew the main piston rings which require a certain amount of attention, depending upon the quality of fuel oil being used, &c. If a piston can only be withdrawn from the top the cylinder head must be removed, necessitating the breaking of the connections belonging to the cooling water supply, fuel, fuel injection air, air suction, exhaust, &c. Some of these are high-pressure connections and better left undisturbed. The disconnecting of the valve gear also becomes necessary. On the other hand, removal of the pistons from below often means a higher engine. The connecting-rod bottom is not of the marine type with palm end, but is as shown in Fig. 3, which design tends to reduce its size and so facilitates the consideration of withdrawal through the cylinder.

The crankshaft for this size of engine is in two pieces, a six-throw shaft for the main engine and a two-throw for the compressors, and it is conveniently made of the solid type. It is drilled for forced lubrication. The lubricating oil is delivered by the pump to the main bearings, passing along the crankshaft to the crank pins, up the connecting rod to the gudgeon pin bearings, through the pipe in the hollow piston rod to the piston, and down outside this pipe to the crank-chamber and to the sump in the bedplate from which the lubricating oil pump draws. The pressures at full piston load on the crankpin and main bearings work out at 1,100 lb. per square inch and 540 lbs. per square inch respectively.

The cylinder head of cast iron contains five valves, the fuel injection valve (6), two inlet valves (7) and two exhaust valves (8). The provision of two inlet and two exhaust valves, which is exceptional for this size of engine, makes easier the provision of ample passage for the air and exhaust, and the fact of having two small exhaust valves in place of 4 single larger one renders unnecessary water cooling of the exhaust valves. These valves (see Fig. 5) have cast iron heads fixed on to steel stems, the better to resist the action of the gases; the baffle to protect the valve spindle guide from the action of the high velocity gases will be noted. The arrangement of the valves does not follow normal practice, in that they are not housed in separate cages, but seat direct in the cylinder head. Valve removal requires the lifting of the cylinder head, and a damaged valve seat requires the fitting of a spare head. The casting of the cylinder head is, however, simplified, and the cooling of the exhaust passage by the water circulation is more direct. The valve springs are neatly housed, although inspection of the springs requires dismantling of the valve driving gear.

The inlet valves draw air from the engine room through the grids shown in Fig. 3, through the pipes (11), Fig. 2, from the underside of the working pistons and from the interior of the engine framing (10). The undersides of the pistons are completely isolated by the diaphragm and gland (see Fig. 3) from the interior of the crank-chamber. This isolation, which can generally be effected with four-cycle crosshead engines, is most desirable. Gases and burnt lubricating oil mixed with a certain percentage of fuel oil passing the main piston rings would otherwise cause contamination of the lubricating oil in the crank chamber. Leak-offs are provided for this oil as shown, and in certain cases, after filtering, this oil has been used over again as fuel. The suction of the main cylinders and of the compressors being coupled up and taken from this common source, makes for silence, keeps gases from entering the engine room and tends to cool the main engine framing. The quality of air drawn into the main cylinders and compressors is impaired in this way to some extent, and although not of much importance where the main cylinders are concerned, is not a commendable feature with high-pressure compressors (1,000 lb. per square inch delivery pressure). The nature of the joint between the exhaust manifold (9) and the cylinder heads may be seen from Fig. 3. Allowance is made for expansion, and the supporting feet of the exhaust pipe are free to slide. The exhaust pipe is water-jacketed, with inspection doors opposite each cylinder.

The valve gear is of novel design for four-cycle engines, the leading considerations having been, facility of reversing and of disconnecting for removing the cylinder heads.

The camshaft (13) is level with the cylinder tops, and is driven by spiral gearing from the crankshaft. There are two cams for each set of valves, *i.e.*, one set for ahead and one for astern. Motion is transmitted from each cam to a lever, and from the lever mounted on the eccentric fulcrum shaft by means of three pull rods to the adjustable tappets on the bell cranks operating the valves. Driving out one pin in the end of each pull rod frees the cylinder head from the valve gear, and on re-assembling the gear is replaced in exactly the same relation to the crankshaft. The cams run in an oil bath (12), and forced lubrication is provided for the valve gear.

Two tandem compressor cylinders, as will be seen from Fig. 2, are driven from a two-throw crankshaft coupled to the forward end of the main six-throw shaft. These cranks are at right angles to each other. The forward lower cylinder (18) serves to compress air for auxiliary purposes to a pressure of 60 lb. to 70 lb. per square inch, and for starting the engine as later explained. The upper cylinder (17) is the high-pressure cylinder of the three-stage compressor. The lower after tandem cylinder (15) is the low-pressure cylinder of the compressor, and also a starting cylinder, while the upper (16) is the intermediate-pressure cylinder. The capacity of this high-pressure fuel injection air compressor is such that the swept volume of the low-pressure piston is 18·75 cub. ft. per hour per brake horse-power of the main engine. The compressor is provided with automatic valves, as at (22) and (23), to all the stages, and intercoolers reduce the temperature of the air between the stages of compression.

The design of the driving gear, crossheads and so forth, is exactly the same as for the main engine. At the forward end of this two-throw crankshaft and driven at reduced speed of revolution by spur gearing, are the forced lubrication oil circulating pump, cooling water pump, daily service fuel oil pump, and bilge pumps suitably grouped together (26). This reduction gearing gives the pumps a speed of revolution of 70 revolutions per minute, and so reduces the shocks of operation of the water pumps.

One of the most interesting features of all marine engines is the arrangement for starting, reversing, control, &c. With the Tosi engine the main cylinders are not used for starting. The disadvantages of introducing starting air to the main cylinders to give the first impulses are considerable. The expansion of the starting air cools the cylinder and its contents, whereas the principle of starting is to revolve the engine at such a speed of revolution that the heat generated by the compression of the air will ignite the injected fuel. For this reason the compression pressure of the Diesel engine is generally governed by the starting condition, and must be such that, allowing for contingencies, sufficient heat will be generated at the relatively low speed of revolution attained when running on starting air to counteract the cooling effect of the expansion of the starting air and ignite the injected fuel. For this reason a much higher compression pressure must normally be carried than, excepting for the starting conditions, would be required. High compressions are not desirable. Again, with slightly abnormal conditions the quantity of fuel that is injected into the working cylinder before ignition takes place may be considerable, and may give rise to high pressures to deal with which safety valves are often fitted to the main cylinders. With the Tosi engine safety valves are not fitted, and as starting air valves are also eliminated the cylinder head only contains the five valves already enumerated. A further advantage, and a very considerable one, is that by carrying out the starting operation without the main cylinders a marine reversible four-cycle engine can be constructed

SIX-CYLINDER FOUR-CYCLE DIESEL ENGINE.

CONSTRUCTED BY MESSRS. FRANCO TOSI, LEGNANO, MILAN.

Fig. 2.

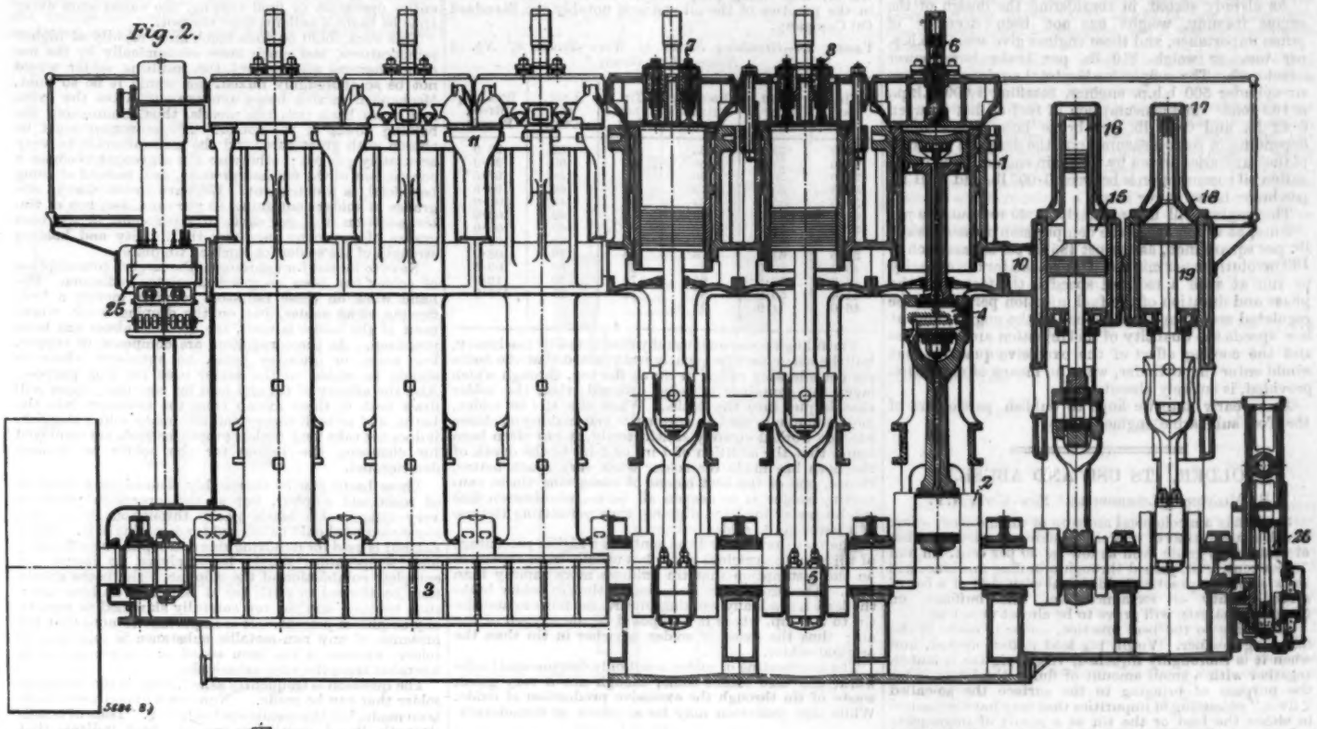


Fig. 3.

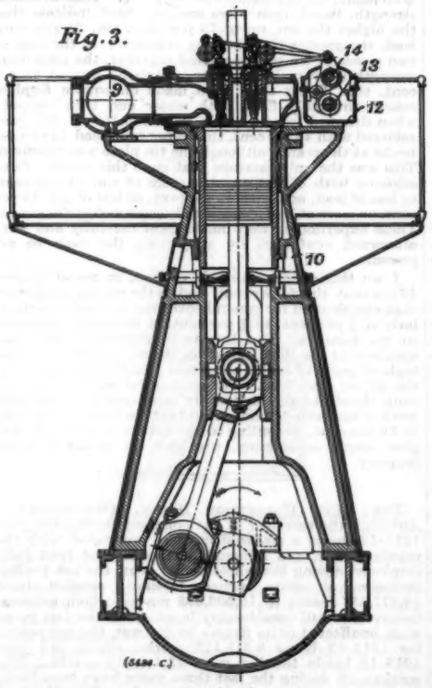


Fig. 4.

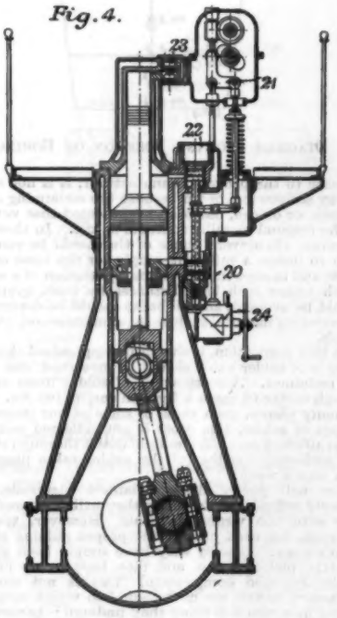
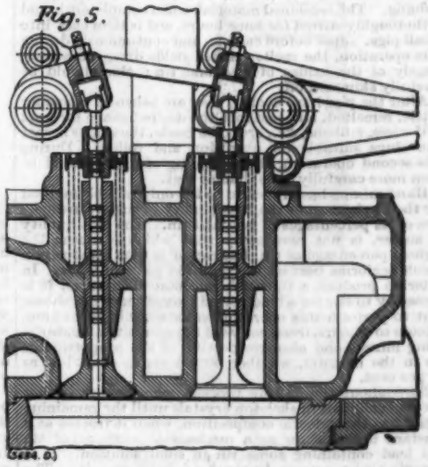


Fig. 5.



with three, four, six or eight cylinders, whereas, when relying on the general method employing starting valves in the main cylinders, in order to be able to start from any position, four-cycle reversible engines must have at least six cylinders. From a manufacturing standpoint the method of starting adopted by Tosi and used by one other maker is a most desirable feature.

Starting is effected by admitting low-pressure starting air some 200 lb. per square inch to the two double-acting cylinders of the compressor group. The lowest pressure of starting air requisite to start the engine is 170 lb. per square inch. The cranks are at 90 deg., so that the engine can be started from all positions. This air is controlled by the piston valves as shown in Fig. 4, from the camshaft driven by special cams through the bell crank lever and rod (20 and 21).

Immediately the engine picks up on fuel, which, for the reasons already stated, requires fewer revolutions than when starting air is admitted to the main cylinders, these starting cylinders are cut out and function normally as compressors. It may be mentioned that a storage capacity of starting air of 1,000 litres is sufficient to reverse the engine 18 times.

The same hand wheel and gear controls the fuel injection pumps (25), which are driven by spiral gearing from the vertical shaft driving the overhead camshaft, and are six in number, one for each working cylinder. The fuel injection pumps are so timed that the delivery stroke of each pump takes place when the cylinder head fuel injection valve is closed and the main cylinder exhaust valve is open, so that in the event of a fue injection valve hanging up, the fuel charge passes into the exhaust pipe, and the danger of high pressure due to the combustion of an accumulation of fuel within the working cylinder is obviated. Hand adjustment is provided for each pump, and an emergency governor cuts out the pumps when the speed of revolution rises to 15 per cent. above the normal. Reversal is accomplished from the same control (24). The cylinder head valve lever fulcrum shaft (14) is rotated, lifting the ahead levers off the cams and depressing them on to the astern cams, and also altering the setting as required of the piston valves controlling the entrance of the low-pressure air to the two starting cylinders. Sight feed forced lubrication is provided to the main pistons.

The engine described is a reversible marine engine, but in most particulars is similar to Messrs. Tosi's land engines. The principal differences in the case of the land engines are the elimination of the reversing gear, double cams, bilge pumps, and the provision, instead of a safety governor, of a governor to take charge of the engine revolutions. For land work, since the engine

can be barred round into position for starting only one compressor is required, the bilge pump is eliminated, and with certain installations no cooling water circulating pump need be provided.

As already stated, in considering the design of the engine framing, weight has not been deemed of prime importance, and these engines give some 7 b.h.p. per ton, or weigh 310 lb. per brake horse-power developed. The weight for the total equipment of two six-cylinder 500 b.h.p. engines, totalling 1,000 b.h.p., is 165 tons. The consumption of fuel oil lies between 0·42 lb. and 0·45 lb. per brake horse-power hour, depending in some measure upon the designed capacity of the auxiliaries driven by the main engine. The lubrication oil consumption is between 0·007 lb. and 0·01 lb. per brake horse-power hour.

The engine will fire regularly at 40 revolutions per minute, at which speed the compression pressure is 450 lb. per square inch, as against 485 lb. per square inch at 165 revolutions per minute. One reason for the capacity to run at such a reduced speed is the fact that the phase and duration of the fuel injection period can be regulated according to the speed of the engine, and at low speeds the quantity of fuel injection air is reduced and the cooling effect of the excessive quantity that would enter the cylinder, were no means of regulation provided, is entirely absent.

At an early date we hope to publish particulars of the Tosi submarine engine.

SOLDER, ITS USE AND ABUSE.*

By MILTON L. LISSBERGER,† New York, N.Y.

SOLDER is a mechanical mixture of tin and lead, a fact which is susceptible of very simple demonstration. A bar of solder of a grade even as low as 30 per cent. tin and 70 per cent. lead, passed through a buffing machine, will show a surface practically identical with that of a bar of second-quality or reclaimed tin. The buffings, on chemical analysis, will prove to be almost pure lead.

According to the best practice, solder is made in the following manner. Virgin pig lead is first melted, and when it is thoroughly liquefied, virgin pig tin is added, together with a small amount of flux; the latter is for the purpose of bringing to the surface the so-called "liver," consisting of impurities that may have remained in either the lead or the tin as a result of incomplete refining. The combined material, when completely liquid is thoroughly stirred for some hours, and is then cast into small pigs. Just before casting, and continuously during this operation, the molten metal yields dross, consisting largely of the oxides of lead and tin; this should be carefully skimmed off.

After the pigs have cooled, they are taken to a smaller kettle, remelted, and cast into the desired shape for use; or if wires, ribbons, &c., are to be made, the solder is cast into slugs suitable for extrusion and rolling. During this second operation, the skimming of dross should be even more carefully done than at first.

Hand mixing has proved to be the only reliable method for the production of the best quality of solder, irrespective of its percentages of lead and tin. The best quality of solder, is not necessarily that which contains the highest percentage of tin, but rather is that composition which performs best on the required piece of work. In order to produce a thorough mechanical mixture, it is necessary to stir for a long period; experience has shown that to perform this operation satisfactorily takes from 5 hours to 6 hours, irrespective of the quantity of material being mixed, and also irrespective of the proportion of tin in the mixture, whether 60 per cent., or as low as 30 per cent.

Throughout the casting process, what occurs is that the lead solidifies in skeleton crystals until the remaining liquid has the eutectic composition, when it freezes at a constant temperature as a mechanical mixture of tin and lead containing some tin in solid solution. It is remarkable how many shapes these skeletons take. The seeming explanation of this variation is the presence of other metals than tin and lead, in very small proportion, or even traces.

An analysis made, in 1901, of borings taken from a section of a pig of solder at the points indicated in the accompanying diagram‡ showed the tin content to be as follows: No. 1, 59·06 per cent.; No. 2, 52·99 per cent.; No. 3, 38·43 per cent.; No. 4, 39·07 per cent.; No. 5, 45·62 per cent.; No. 6, 39·33 per cent.; No. 7, 38·82 per cent. Table I gives the breaking stress of 25 grades of wire solder of No. 9 Birmingham gauge; tin wire of this gauge breaks when subjected to a stress of 120 lb. and lead wire, when subjected to a stress of 48 lb.

With the idea of conserving tin, solders should be separated into two classes:—

(1) That which is used strictly for soldering, that is, joining and holding together two pieces of metal.

(2) That which is used primarily for the filling of an interlocked joint, so as to prevent the escape of the contents of a container. It is these filling metals that offer the greatest opportunity for the conservation of tin. It is only necessary that the metal shall flow into the seam, and solidify into an impenetrable mass.

* Paper read before the American Institute of Mining Engineers (slightly abbreviated).

† President, Marks Lissberger and Son, Inc.

‡ For this diagram and the table appended the author is indebted to Dr. G. W. Thompson of the National Lead Company.

The greatest abuse of solder occurs in the use of high-tin mixtures for filling metals. A mixture of 25 per cent. tin and 75 per cent. lead, worked at the right temperature and with proper fluxing, is high enough in tin for any filling purpose, as has been demonstrated in the practice of the oil canners, notably the Standard Oil Company.

TABLE I.—*Breaking Stress of Wire Solder of No. 9 Birmingham Gauge.**

Tin, per Cent.	Lead, per Cent.	Breaking Stress, Pounds.	Tin, per Cent.	Lead, per Cent.	Breaking Stress, Pounds.
25·0	75·0	65	48	52	93·0
28·0	72·0	68	50	50	95·0
30·0	70·0	69	52	48	97·0
33·3	66·6	73	54	46	98·5
35·0	65·0	74	56	44	101·0
36·5	64·5	78	58	42	103·0
37·0	63·0	79	60	40	105·0
38·0	62·0	80	62	38	106·5
38·5	61·5	78	64	36	108·0
40·0	60·0	84	67	33	109·5
42·0	58·0	85	70	30	112·0
44·0	56·0	87	75	25	115·0
46·0	54·0	91			

The filling operation is usually conducted by machinery, but the users have frequently not realised that the baths are considerably richer in tin at the top, through which layer the container is being dragged, than the solder that is put into the baths. When the 40 : 60 solder, most commonly used on automatic can-making machines has not worked entirely satisfactorily, it has often been found that the addition of 1 in. or 2 in. to the depth of the bath has made the solder work very much better. Hence, one of the best means of conserving tin in can-making solder is to deepen all baths, whether on line machinery or for hand dipping, thus permitting the use of a lower-grade solder.

The fact that solder dross contains a higher percentage of tin than the original solder has usually been explained on the assumption that tin oxidizes more rapidly than lead. The probable explanation is that in solder baths the lead is gradually working toward the bottom and the tin to the top, where it is exposed to the oxygen of the air; thus the oxide of solder is richer in tin than the original solder.

The overheating of solder is not only detrimental to the work, but also causes some, though not a very great, waste of tin through the excessive production of oxide. While this oxidation may be a source of considerable

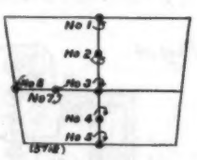


DIAGRAM SHOWING POSITION OF BORINGS.

expense to the package manufacturer, it is not actually a very serious loss of tin because the reclaiming of these drosses, or oxides, has been so perfected that very little of the original metallic contents is lost. In these days, however, when every ounce of tin should be conserved, both to insure a sufficient supply for the most essential work, and to save the useless transportation of a material which comes such long distances by boat, overheating should be avoided, and all baths should be covered with a protecting material such as sal ammoniac, oil, charcoal, or ash.

In this connection, it should be emphasised that every particle of solder oxide should be preserved, and sent to the reclaimer. A teaspoonful of solder dross contains enough solder to make a 5-gallon can or 100 No. 1 cans. In many plants, even those of some of our largest consumers of solder, this dross is not collected and saved with sufficient care. It is seldom that a thorough cleaning and gathering together of the oxides takes place more than once a week.

Fire will purify these reclaimed materials, when properly refined, and in purity they will compare favourably with the virgin materials. However, too little attention has been paid to the proper refining of these scrap metals. Usually they have simply been put into a kettle, melted down, and then brought up or down to the required composition. This is not sufficient. Reclaimed metals are never equal to virgin metals, no matter how much refining they undergo; nevertheless, for certain classes of work they are economical and efficient. The repeated use of metal affects its physical permanency; yet the margin of safety in the use of solder is so large, and the length of time that solder is required to remain on the container is so comparatively short, that any lack of permanency can usually be safely disregarded.

After many years of experience, we have developed the following method of manufacture. The lead is first melted at a temperature which does not cause too rapid fusion. After the dross has had a chance to rise to the surface, it is carefully skimmed off before the required amount of tin is added, and slowly reduced to the liquid state. From the moment the tin is added, the solder is stirred by hand for 3 hours to 4 hours. A scavenger is then added and thoroughly worked for another 3 hours to 4 hours; the resulting dross is again skimmed, and the solder is cast into pigs of approximately 80 lb. each. These pigs are then re-melted in smaller kettles at a temperature which just causes free fluidity, and the solder is then cast into the desired shapes. During the entire operation of final casting, the caster stirs every time he takes a ladleful from the pot.

This work could be done much more rapidly at higher temperatures, and much more economically by the use of mechanical mixers, but the resulting solder would not be so thoroughly mixed, nor would it be so fluid. Mechanical mixing has a tendency to drive the oxide and dross back into the metals, thus diminishing the holding power of the solder. The scavenger must be chosen with great care, and the amount must be very accurately gauged; otherwise the scavenger becomes a constituent of the finished product, and, instead of being beneficial, is a detriment. We have found that in the grades of solder containing 46 per cent. and less of tin, the addition of ¼ per cent. to ½ per cent. of the best grades of antimony increases the fluidity and holding strength of the solder for working tin plate.

Next to its use for containers, the largest consumption of solder has been on gasolene motor radiators. The hand work on these radiators requires merely a free-flowing clean solder, but on the dipping work, where most of the solder is used, the greatest abuse has been practised. As these radiators are composed of copper, low brass, or ordinary brass, no antimony whatever should be added to the solder used for this purpose. Also the affinity of tin and lead for zinc and copper will draw both of these metals from the radiators into the baths, and as both copper and zinc make solder sluggish, it does not take long (unless proper methods are employed for cleansing the baths) for the solder to become deteriorated.

These baths can be thoroughly cleaned by a mixture of rosin and sulphur, but as this operation produces very disagreeable black smoke throughout the plant, some method should be devised for disposing of it. When sulphur is used for removing zinc and copper, a sufficiently high temperature should be employed to insure the complete combustion of the sulphur. The baths should then be allowed to settle for at least half an hour after such heating, and the top carefully skimmed to remove any sulphides present. It is important to note that the presence of any non-metallic substance is injurious to solder, whether it has been added as a scavenger or is liberated from the original metals.

The question is frequently asked, what is the strongest solder that can be made. Numerous experiments have been made, but the results are confusing. Tests of tensile strength, based upon wires and cast bars, indicate that the higher the tin, up to 75 per cent. tin, 25 per cent. lead, the greater the breaking strength; in the case of two pieces of tin plate soldered together, the maximum strength is given by a solder containing around 42 per cent. tin. Other tests were made on square 5-gallon cans, completely filled with water and then capped; when dropped from a height of about 100 ft., the cans soldered with 46 per cent. tin, 54 per cent. lead, in no case broke at the seams, although the tin plate was ruptured. This was the only mixture that gave this result. Cans soldered with 47 per cent. or more of tin, 53 per cent. or less of lead, and with 45 per cent. or less of tin, 55 per cent. or more of lead, occasionally ruptured at the seams. These experiments were made most carefully and were afterward confirmed by subjecting the cans to air pressure.

I am thus inclined to believe that, in round figures, 46 per cent. tin, 54 per cent. lead, is the strongest mixture that can be used for general soldering purposes, particularly if ¼ per cent. to ½ per cent. of antimony be added to the mixture. The Bureau of Standards, with the approval of the War Industries Board, suggests that the highest grade of solder permitted should be 45 per cent. tin, 55 per cent. lead. For mechanical soldering, 40 per cent. should be the highest tin ratio, and for most bath work it has been demonstrated that tin from 35 per cent. to 38 per cent., according to the nature of the work, will give ample satisfaction, provided the solder is made properly.

* Experiments made by F. W. Schultz and recorded in his book on "Solder" published in 1908.

THE GUTE HOFFNUNGS HÜTTE, OBERHAUSEN.—Although the turnover of the company during the year 1917–18 shows a material increase compared with the previous year, and although the works had been fully employed during the whole of the year, the net profits, exclusive of sums carried forward, receded from 18,477,532 marks to 15,506,098 marks, which amount, however, is still considerably in excess of the last peace year, unaffected in its figures by the war, the net profits for 1912–13 being 9,513,112 marks, whilst the year 1915–16 heads the list with 23,407,816 marks. The writings-off during the last three years have been fairly stationary at about 10,000,000 marks. The dividend was fixed at 20 per cent., the same as for the two preceding years. The shipping and coal trading concern of Frantz Haniel and Co. has extended its business, and taken part in the formation of the Schwaben Shipping Company. The expectations entertained as to the doings of the Haniel Company have been fulfilled. The Gute Hoffnungs Hütte has become interested in the Hamburg Shipyard, and jointly with the Allgemeine Elektricitäts Gesellschaft, the company has founded the German yard (Deutsche Werft) in Hamburg, and has secured a leading control in this new shipbuilding undertaking. The Gute Hoffnungs Hütte has further purchased the Altenbundem Rolling Mills and Hammer Works. The company's buildings and plant stand booked at 95,000,000 marks. The holdings of bonds and stocks have risen to 23,130,000 marks against 16,720,000 marks a year ago.

VALVES AND FITTINGS FOR HIGH HYDRAULIC PRESSURES.*

By WM. W. GAYLORD, Torrington, Conn.

WITH the greater use of hydraulic machines of various sorts as the result of the large manufacture of munitions, a greater interest is to be expected in the design of valves and fittings for such machines. This paper gives the results of my experience, and I have written it largely in the hope that others may be led to publish the results of theirs.

A few years ago when the problem was presented to me of designing a new hydraulic system for a working pressure of 5,000 lb. per square inch, with the probability that this would be increased to 7,500 lb. per square inch, I found there had been very little published on the design of valves and fittings for this pressure, and that the designing formulæ given in standard handbooks were either incorrect or unsatisfactory. The formula most generally given was that of Lamé, based on the maximum-stress theory, which, while correct for cast-iron is not satisfactory for steel. Lanza, in his "Applied Mechanics," gives a modification of the Grashof formula based on the maximum-strain theory which I had used before with fair results for steel fittings on lower pressures. I had, however, noticed some unaccountable failures when it was applied to pipe and fittings using a working pressure of 4,000 lb. to 4,500 lb. per square inch.

While studying these failures my attention was called to the maximum-shear theory proposed by Guest, and this seemed to explain most of them. About this time the results of the experiments of Cook and Robertson were published in ENGINEERING, December 15, 1911, and after considerable study I became convinced that these offered the best basis for design.

The form in which they give the formula for fibre stress, based on the maximum-shear theory, is

$$\frac{P}{f} = \frac{K^2 - 1}{2\,K^2}$$

where P is the internal pressure in pounds per square inch, f the fibre stress, and K the ratio of external to internal diameter. This is the equivalent of the usual formula:

$$f = P\,\frac{2}{1 - \frac{d_0^2}{d_1^2}}$$

where d_0 is the internal diameter, and d_1 the external diameter.

The results of their experiments show that if a factor of 1·2 were introduced the equation would more nearly represent the actual results, so the formula suggested by them becomes:

$$\frac{P}{f} = 1.2\,\frac{K^2 - 1}{2\,K^2}$$

By substituting $\frac{r + t}{r}$ for K in this formula, the thickness t of cylinder wall of a cylinder of inside radius r becomes

$$t = -r \pm \sqrt{\frac{P\,r^2}{0.6\,f - P} + r^2}$$

From this formula it is apparent that a material having a working fibre stress of 12,500 lb. per square inch or less would not be safe however thick the pipe wall. This, of course, eliminates bronze, cast-iron and semi-steel as materials for making these fittings. After careful consideration of the materials available it was found that cold-drawn seamless steel pipe annealed to give 45,000 lb. per square inch elastic limit, and steel castings for fittings giving 30,000 lb. to 35,000 lb. per square inch elastic limit, could be obtained, and it was decided to use these.

As the system had no accumulator and therefore was not subjected to severe shocks, a working fibre stress of 0·6 of the elastic limit was used.

The largest pipe in the system was to take the discharge of five pumps, each of 60 gallons per minute capacity, making a maximum flow of 300 gallons per minute, but most of the time only three pumps, or 180 gallons, would be used. In view of this a maximum velocity of 20 ft. per second or a usual velocity of 12 ft. per second was allowed which required a pipe of 2½ in. inside diameter. From the above formula the thickness required for a pipe of 2½ in. inside diameter is:

$$t = -1.375 \pm \sqrt{\frac{7500 \times 1.375^2 \times 2}{0.6 \times 27000 - 7500} + 1.375^2}$$

$$= -1.375 \pm \sqrt{\frac{28360}{17400} + 1.891} = -1.375 \pm 1.876$$

$$= 0.51 \text{ in.}$$

and for a fitting:

$$t = -1.375 \pm \sqrt{\frac{7500 \times 1.375^2}{0.6 \times 19500 - 7500} + 1.375^2}$$

$$= -1.375 \pm \sqrt{\frac{28360}{8400} + 1.891} = 0.925 \text{ in.}$$

A pipe having 4 in. outside and 2½ in. inside diameters was chosen, as this was a commercial size and allowed the necessary thickness of metal for threading to use in a joint of the type shown in Fig. 1. The fittings were made with a 1-in. wall thickness, the tee shown in Fig. 2 being an example of the type used.

The bolting of the flange was figured by assuming that the full pressure was applied to the area of a circle of the outside diameter of the gasket. In the joint in Fig. 1 this would make a total load on the bolts of (1·875)² × 3·142 × 7,500 = 83,150 lb., which would require eight 1½ in. bolts if U.S. standard bolts were used, allowing a working fibre stress of 10,000 lb. per square inch. This would have taken a flange about 11 in. in diameter and would have made the piping very hard to install in the limited space available, so it was decided to use bolts made to the S.A.E. or, as it was then known, the A.L.A.M. standard. Using a working stress of 22,500 lb. per square inch, this allowed the use of eight ¾-in. bolts in an 8½-in. flange. This is open to the objection that a careless mechanic may replace these special bolts with standard bolts and thus cause the failure of the joint, but there has been no trouble from this cause.

When the piping was installed, some of the gaskets were of soft copper and the rest of red fibre, but experience has shown red fibre to be more satisfactory as the copper soon hardens and a slight water hammer will often start the joints leaking, while the red fibre does not give this trouble.

The system was to supply three machines from a group of five pumps, and the piping was to be so arranged that the large machine, which was to use pressures up to 7,500 lb. per square inch, could be operated with any or all of the pumps, while the other two machines were to be operated with one or two pumps each, but the connections were to be so made that any pump could be

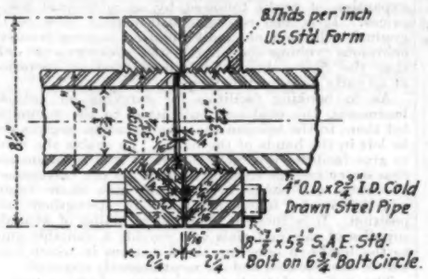


FIG. 1 TYPICAL FLANGED JOINT FOR 7500 LB. PER SQ. IN.

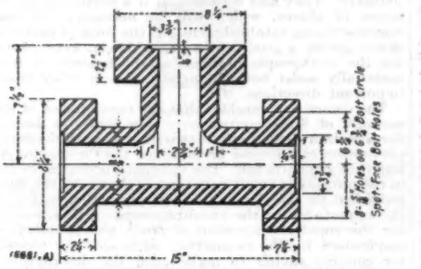


FIG. 2 TYPICAL FLANGED FITTING FOR 7500 LB. PER SQ. IN.

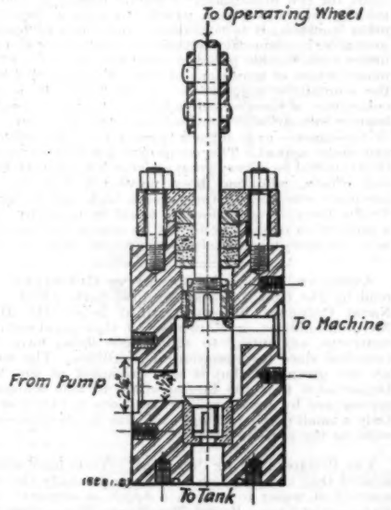


FIG. 4 OPERATING VALVE FOR 5000 LB. PER SQ. IN.

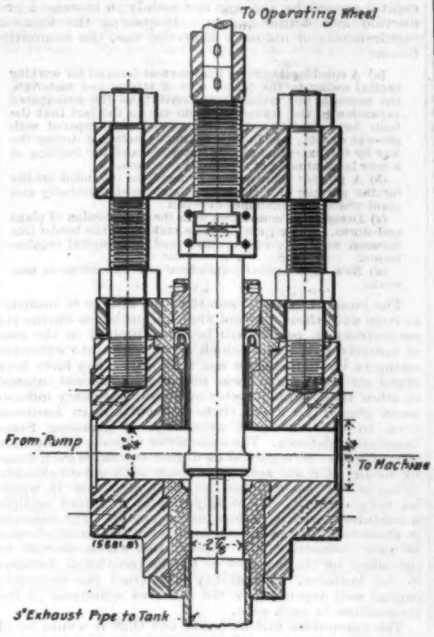


FIG. 3 OPERATING VALVE FOR 7500 LB. PER SQ. IN.

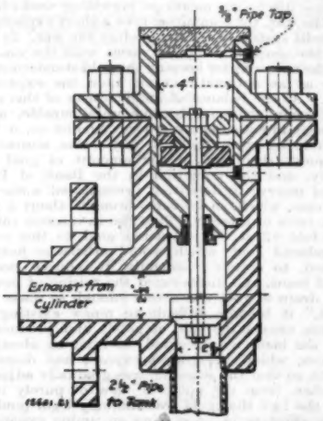


FIG. 5 CAST-STEEL EXHAUST VALVE USED TO REPLACE VALVE IN FIG. 6

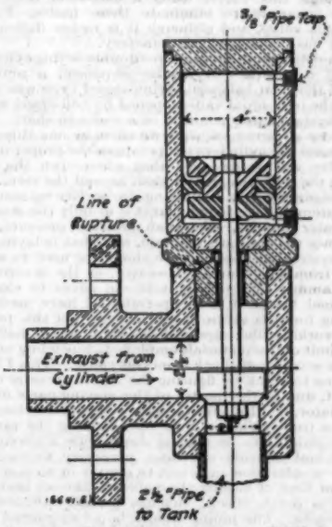


FIG. 6 EXHAUST VALVE FOR 5000 LB. PER SQ. IN.

* Abstract of paper read before the American Society of Mechanical Engineers at New York, December, 1918.

connected to any machine. This was done by using a manifold tee on the discharge of each pump with a valve connecting to each pipe line.

The valves originally put in were of two types: one a wedge gate valve with cast steel body and hard bronze wedge, the other a stop valve of the balanced type having cast steel body and bronze plunger. The gate valves proved impracticable as the bodies could not be made sufficiently rigid to prevent distortion of the seat and the starting of a leak which would grow very rapidly because of the cutting action of the water. The other valves were more satisfactory and could be kept fairly tight by frequently dressing the seat and plug; but it was found more satisfactory to use blank flanges and pipe spools in place of the valves to make necessary changes in connections.

The machines were in effect single-acting presses in which the ram was returned by an auxiliary low-pressure system. The main operating valve therefore became a bypass valve which was closed to drive the ram forward and opened to allow the ram to stop and be returned. The valve in Fig. 3 was chosen for this place and was first made without the loose connection shown in the stem, but it was found very hard to open it after it had been shut tight, so the connection was added and this difficulty overcome. Experience had shown that the form of seat used with the bevelled recess for the plug would last much longer than if the valve had a flat seat.

This system has been in use five years, often with a working pressure of 8,000 lb. per square inch for short periods, with no failures, and, with the exception of the valves mentioned, has given good satisfaction.

On two similar systems, more recently installed for operating pressures of from 4,000 lb. to 5,000 lb. per square inch, the same type of pipe and fittings has also been used with success. The operating valves furnished for these systems were made as shown in Fig. 4 and proved unsatisfactory, as the water pressure on top of the plug held the valve closed so that it was almost impossible to open it. These were replaced by valves similar to Fig. 3, which are working satisfactorily.

These machines had an exhaust valve, as shown in Fig. 6, which returned the water direct from the main cylinder to the tank on the return stroke of the ram. These gave much trouble by the intermediate piece between the valve body and operating cylinder breaking through as indicated. This in two cases blew the operating cylinder entirely off the valve body. Two of the valve bodies also failed by splitting. In view of this and the fact that a leakage through the U-leather packing might also blow the operating cylinder off, it was decided to redesign this valve, using a cast-steel body and cylinder arranged to eliminate these faults. Fig. 5 shows this valve, and although it is rather difficult to build, it has proved very satisfactory.

On a smaller press having three double-acting cylinders designed to operate in regular sequence, a multiple valve of the semi-balanced spring-closed type was used, having the individual valves opened by bell-crank levers moved by face cams mounted on a common shaft. The cams were so arranged that rotation in one direction would cause the cylinders to operate in the proper order. The valve was so designed that when open the area through the seat was greater than around the stem.

In designing valves and fittings for service on accumulator systems I have found that it is usually the severity of the water hammer, rather than the actual pressure, that determines the strength required, and that in laying out such a system all possible care should be used to avoid trouble from this source. However, as the severity of water hammer in a new system can never be exactly determined before it is in operation, I have used the designing formula given in the first part of this paper, with a working fibre stress of one-third to one-half the elastic limit of the materials employed, depending on the probable severity of shock from this cause. This I have attempted to check by figuring the rise of pressure to be expected, due to the inertia of the moving parts of the accumulator, if all operating valves should be closed at the same time. This is done by assuming the ram of the accumulator to be coming down with a maximum velocity and figuring the force necessary to cause a negative acceleration sufficient to stop it in an assumed minimum time of closing the valves. This at best can only be a rough check, but has proved sufficient in several cases. The piping should be so supported and anchored that water hammer will not cause any considerable whip, as this is the usual cause of broken fittings and leaking joints.

The valve most used to control single-cylinder machines, like draw benches on an accumulator system, is a combined throttle and reversing valve, while the valves for multi-cylinder machines are too numerous and complex to describe in this paper; but the principles used in their design are the same as for the valve already described, except that greater care must be exercised to prevent too rapid opening and closing and consequent destructive water hammer.

THE WAR LOSSES OF THE SCANDINAVIAN MERCHANT FLEETS.—The losses of the Swedish merchant fleet from war casualties amount to 178 vessels, with an aggregate tonnage of 200,570 reg. tons gross; 248 lives have been lost. The loss of vessels represents 17 per cent. of the country's total tonnage; new construction and purchases have not been sufficient to make up for the losses. The losses of the Danish merchant fleet comprise 250 vessels, with an aggregate tonnage of 255,597 reg. tons gross. With the Norwegian losses amounting to the heavy total of 1,240,669 tons, the aggregate losses of the three Scandinavian countries come out at about 1,700,000 tons, whilst some recent English statistics gave the aggregate losses of all the neutral European countries as only 1,500,000 tons.

FINANCE AND TRADE.

THE Committee on the Provision of Financial Facilities for Trade After the War was appointed jointly by the Chancellor of the Exchequer and the Minister of Reconstruction in November, 1917, under the chairmanship of Sir Richard D. Vassar-Smith, of Lloyds Bank. They introduce their Report (now published by the Ministry of Reconstruction) by expressing the emphatic opinion that the primary factor in repairing the wastage of capital caused by the war lies mainly in increased production and actual saving. Discussing the financial requirements of industry after the war, the committee foresee:—

(*a*) A considerably more than normal demand for working capital owing to the higher cost of labour and materials, the necessity for giving longer credit and the anticipated expansion in the volume of trade due to the fact that the basis for potential commercial output, as compared with pre-war output, has been very greatly enlarged during the war by the extension of existing works and the building of a very large number of absolutely new ones.

(*b*) A greater than normal demand for extended credits for the purpose of replacing at higher cost machinery and plant which has fallen into disrepair.

(*c*) Demands in connection with the reconversion of plant and works. These in many cases may be on the border line between working credit facilities and new capital requirements.

(*d*) New fixed capital requirements for extensions or new works.

The committee point out that the ability of industry to cope with these unusual financial problems during the reconstruction period will be most limited in the case of entirely new firms, which have come into existence owing to the demand for war material. They have been urged strongly that it was not in the national interest to allow these firms to peter out, and that every inducement should be given them to continue in business, even to the extent, if necessary, of granting State financial assistance. The committee express the opinion that it might be regarded as unjust to enable such firms, by means of State aid, to compete with old-established firms in the same industries, and also that it would be very difficult, if not impossible, to guard against wastefulness and inefficient management. The solution in these cases appears to them to lie in the establishment of new industries, the capital for which should be furnished by the investor or by the individual partners in the business. The ability to attract the necessary capital will depend upon the inherent soundness of the proposition in each case.

The committee further point out that it would be of great assistance to manufacturers in making plans for the future, if the future policy of the Government were made known as early as possible in regard to: (*a*) fiscal policy; (*b*) rationing of raw materials; (*c*) the break clause in connection with the termination of munition contracts; (*d*) the disposal of national factories and surplus stores.

Before discussing means of providing credit facilities after the war, the committee give a short explanation of our credit system as existing before the war. In normal times the amount of credit varies with the amount of gold, the necessity for keeping the gold standard effective acting as an automatic check upon the expansion of credit. As the balance of indebtedness of this country with foreign countries became unfavourable, and the exchanges in consequence moved against us, it became profitable to export gold to pay debts abroad. The consequent shrinkage in the amount of gold in the country, and the reduction in the Bank of England ratio of reserve to liabilities, necessitated a rise in the Bank rate, which, in its turn, brought about a general rise in rates of interest. This rise in interest rates had a two-fold effect. It attracted gold to this country, and induced gold, which would otherwise have been exported, to remain; secondly, it induced people to pay off loans, and discouraged the raising of new ones. If the drain of gold was severe enough to make money "tight," it became difficult to renew existing loans, and this caused the sale of goods and produce upon which the loans were secured, so bringing about a fall in prices, which encouraged exports and discouraged imports, so that the situation was gradually adjusted.

Further, from the point of view of purely internal trade, the fact that gold was the only legal tender was equally effective in preventing an undue expansion in credit, banks being obliged to maintain a proper relation between the extension of credit facilities and their available supply of gold. Thus the gold standard acted as a wholesome restraint upon overtrading, and often adjusted situations which, unchecked, might have developed into a severe commercial crisis.

The position to-day is entirely different. As there is no free international market in gold, the operation of the foreign exchanges has been interrupted, while at the same time the internal gold circulation has been replaced by a currency note issue. As there is no legal limit to the amount of currency notes which may be issued, there is, therefore, no automatic check upon the expansion of credit. The very large extent to which expansion has taken place is shown by the fact that whereas the total deposits at the banks of the United Kingdom, exclusive of the Bank of England, amounted at the end of 1913 to 1,070,000,000*l.*, the amount of deposits is now nearly 2,000,000,000*l.* The enormously increasing purchasing power thus created has, in the committee's opinion, been one of the main factors contributing to the general rise in prices.

In regard to the position after the war, the committee express the opinion that it is essential for the reconstitution of industry and commerce to impose restrictions as soon as possible upon the creation of additional credit by the restoration of an effective gold standard. To attempt to rebuild industry by the further indiscriminate expansion of credit would endanger our position as the financial centre of the world, and would inevitably lead before long to grave disaster. The committee accordingly recommended the cessation of State borrowing as early as possible, all available money being required for the financing of commerce and industry. The committee also consider that any Government guarantee to bankers to enable them to provide by means of credits for fixed capital expenditure for the reconstitution of industry is undesirable, as being likely to occasion a further expansion of credit followed by an additional rise in prices. It is also recommended with a view to the gradual reduction of credit inflation, arising from the enormous volume of short-dated Government debt, that the State should undertake funding operations at an early date for this purpose.

As to banking facilities for carrying on ordinary businesses, the evidence submitted to the committee led them to the opinion that the situation might safely be left in the hands of the banks. To enable the banks to give facilities for extended credit it is recommended that every facility should be given by the Government to enable the banks to issue any new share capital which may be found necessary to strengthen their position. It is thought that the rationing of available supplies of raw materials will provide a valuable guide to the banks in selecting the directions in which loans will be best secured and are most urgently required.

The policy of trade organisation which is now in evidence is welcomed by the committee as furnishing a sound basis for the granting of credit facilities to industry. They also believe that if a portion of the new issues of shares, which will be necessary for many manufacturing establishments, in the form of preference shares giving a good return in dividends, were reserved for the workpeople in these establishments, it would materially assist both financially and in other equally important directions.

The committee consider that the continuance of some measure of State control over new issues is desirable for a certain period, and that with a view to the further prevention of unsound promotions, the Companies Acts might be strengthened. The enormous potential increase in the number of small investors, as shown by the figures published by the National War Savings Committee, and the importance of the encouragement of this tendency for the rapid reconversion of trade and industry, are emphasised by the committee, as is also the necessity for genuine saving to make good the destruction of capital during the war.

In regard to State aid, while the committee does not recommend the guaranteeing of banks by the Government for the investment of public money in loans to persons who have been unable to obtain them from other quarters, it is considered that cases of hardship may arise in connection with firms who have undertaken, under considerable pressure from the Government, the manufacture of munitions of war. To meet such cases, the committee suggest the establishment of a small committee of Government officials and business men in leading industries to consider claims of this kind in the first instance—or to act as a tribunal to which applicants can make appeal. The committee are also of opinion that it would be of very great assistance to manufacturers and others, who had been prevented from forming adequate reserves by the present high rate of Excess Profits Duty, if arrangements could be made by which a proportion of the tax should be retained for a period as a loan upon terms likely to secure early repayment.

AMERICAN ORDNANCE CONTRACTS CANCELLED.—We read in *The Iron Age* that Admiral Earle, chief of the Naval Ordnance Bureau, testified before the House Naval Committee, on November 19, that naval ordnance contracts, amounting to 420,359,000 dols., have been cancelled since the cessation of hostilities. The details are not given out, but it was explained at the Navy Department that the largest share of this amount is represented by naval projects that have not been begun. Only a small portion, it was said, was involved in actual work at the present time.

THE CONSISTENCY OF CONCRETE.—Tests have demonstrated that there is such a thing as precisely the right amount of water to mix in a batch of concrete, says *Engineering News—Record*, New York. More or less than this amount reduces compressive strength. On the actual job, however, such things as the method of placing or the rise or congestion of the forms, make it usually necessary to use a different proportion of water from that which will give the greatest strength in an isolated specimen of the same concrete under laboratory conditions. This variation from the right amount of water must be regulated by the skill and experience of the director of the concreting, so that, in spite of the accepted necessity for a definite water-content, there is to-day more difficulty in determining the proper consistency of a concrete mix than there was in the old days when the amount of water used was a more or less negligible factor. What is lacking is some definite criterion of consistency which may be used as a measure of future strength. The need for this criterion is nowhere more clearly seen than in the manufacture of the numerous concrete barges and ships now under way. Ship construction must be of the best. The thin walls must be of maximum density and strength. The above statements from our American contemporary remind us of remarks which were made by Sir Hugh Bell at a former meeting of the Iron and Steel Institute (see ENGINEERING, vol. lxxxvii, page 684), to the effect that "... a very large number of buildings in the United States, and also in this country, were being erected in concrete, with iron reinforcement, under conditions of insufficient knowledge on many points. ..."

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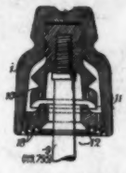
ELECTRICAL APPARATUS.

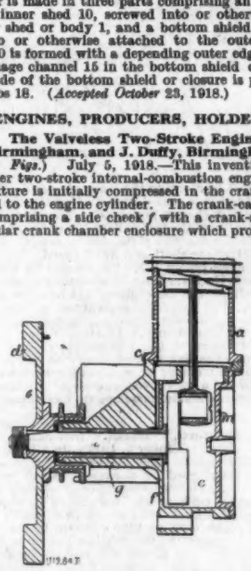
119,795. Taylor, Tunnicliff and Co., Limited, Hanley, and E. D. M. Scrivener, Eastwood, Hanley. Insulators. (7 *Figs.*) February 13, 1918.—According to the invention, the insulator comprises an outer shed 1, and an inner shed 10, in combination with a base piece or disc 12, attached to or carried by the outer shed 1, in order nearly to close the open lower end of the insulator and thus shield the inner shed 10 from the effects of spray, besides producing an extended insulation surface between



the line wire and the insulator bolt or support 9. Preferably the insulator is made in three parts comprising an outer shed or body 1, an inner shed 10, screwed into or otherwise attached to the outer shed or body 1, and a bottom shield or closure 12 screwed into or otherwise attached to the outer part. The inner shed 10 is formed with a depending outer edge 11, situated over a drainage channel 15 in the bottom shield or closure and the under side of the bottom shield or closure is provided with V-shaped ribs 18. (*Accepted October* 23, 1918.)

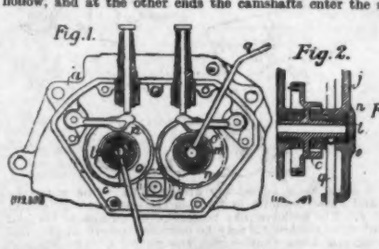
GAS ENGINES, PRODUCERS, HOLDERS, &c.

119,843. The Valveless Two-Stroke Engine Company, Limited, Birmingham, and J. Duffy, Birmingham. Crank Cases. (3 *Figs.*) July 5, 1918.—This invention relates to single-cylinder two-stroke internal-combustion engines in which the fuel mixture is initially compressed in the crank-case before being passed to the engine cylinder. The crank-case *c* is a single structure comprising a side cheek *f* with a crank-axle bearing *g* and an annular crank chamber enclosure which projects from the



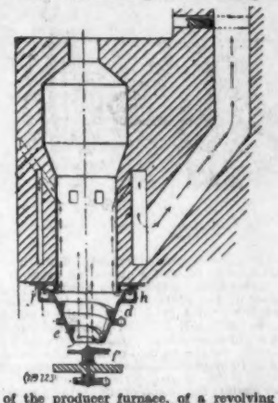
side cheek *f* and provides a continuous seating for the cylinder *a* and the means for attaching the case. The annular enclosure leaves a side opening to the crank-case which is closed by a removable closure piece *m*. The side opening closed by a removable closure piece facilitates assembling and dismantling of the engine as the whole of the crank-case may remain in position while the cylinder, piston, crankshaft and connecting rod are removed. (*Accepted October* 23, 1918.)

119,809. J. L. Norton, Aston, Birmingham. Internal-Combustion Engines. (3 *Figs.*) March 9, 1916.—This invention relates to the mechanical lubrication of internal-combustion engines. *a* represents the crank-case, *e* is the inlet valve cam and *d* the exhaust valve cam. The timing gear cover *j* receives the outer ends of the camshafts *l*, *m*, which are formed hollow, and at the other ends the camshafts enter the side of



the crank-case *a*. The camshafts *l*, *m*, are each perforated at two opposite points, as at *n*, and the bush *o* in each case has a larger port with which a pipe communicates as shown. A pipe *p* from the bush *o* of the inlet valve camshaft *l* communicates with the atmosphere so that any crank-case compression on the suction and power strokes of the piston will be dissipated through the hollow shaft *l*, perforations *n* and pipe *p*. Similarly a pipe *q* from the bush *o* of the exhaust camshaft *m* is carried out from the gear-case to a suitable lubricating oil supply, so that on the compression or exhaust strokes of the piston the suction formed in the crank-case draws lubricating oil into same through the perforations *n* and hollow shaft *m*. (*Accepted October* 23, 1918.)

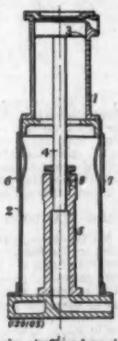
119,723. S. Glover, St. Helens, J. West, Southport, and West's Gas Improvement Company, Limited, Miles Platting, Manchester. Gas Producers. (3 *Figs.*) October 23, 1917.—This invention provides improved means for extracting ash from the producer furnace and for ensuring a more uniform rate of gas production throughout the furnace by providing for a uniform depth or thickness of incandescent coke through which the air or gases being acted upon pass, and for the withdrawal of the producer gas at points distributed around the furnace. The invention comprises the arrangement at the



lower end of the producer furnace, of a revolving member *d* having an inwardly-projecting spiral rib *e* upon its interior, which acts, during the rotation of the member, to draw ashes down the furnace and discharge them from the lower open end, beneath which is situated a plate *f* to prevent self-discharging of the furnace. The invention further comprises the provision at the upper end of the ash-extracting element aforesaid, of an annular trough-like part A to form a water seal, and the arrangement, if desired, of means *j*, for admitting steam or any other gas or vapour to the furnace at about the upper end of the extractor. (*Accepted October* 23, 1918.)

HYDRAULIC MACHINERY.

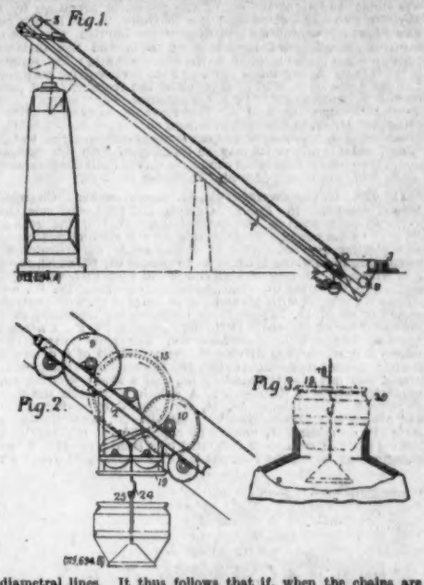
120,105. J. Fielding, Upton St. Leonards. Hydraulic Pressure Intensifiers. (3 *Figs.*) November 6, 1917.—The invention relates to that class of pressure intensifier wherein a large piston operates a hydraulic ram of smaller diameter for the purpose of producing a higher pressure for operating a hydraulic press associated with the intensifier. The invention consists in improved means for effecting the return stroke of the piston and ram. The steam or air cylinder 1 with its piston 3 is carried on a closed casing 2, which constitutes the reservoir or clearance space for air which is initially at atmospheric pressure. 5 is the hydraulic cylinder which, with its ram 4, may be either wholly or partially contained within the reservoir or clearance space within casing 2, and in such case only a single stuffing-box or packing will be necessary, namely, that of the hydraulic ram



and cylinder. A single stuffing-box is shown at 8. When the above arrangement is adopted, glass or other transparent and suitably-located doors 6 and 7 may be provided so that the stuffing-box may be observed from the outside. There is a branch connected to the usual low-pressure water reservoir and the hydraulic press. Under normal working conditions, the air within casing 2 is initially at atmospheric pressure, this being sufficient, with the help of the pressure in the water reservoir, to cause the return stroke of the piston and ram with suitably proportioned moving parts. When steam is admitted to the cylinder and the piston 3 descends, this air is compressed. The extra resistance due to this compression ensures a prompt and quick return movement of the piston when steam is exhausted from the top of the cylinder. (*Accepted November* 6, 1918.)

LIFTING AND HAULING APPLIANCES.

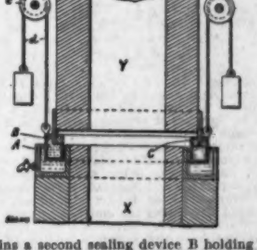
119,694. Blast Furnaces and Equipment, Limited, Westminster, London, and F. Ritson, Westminster, London. Hoisting and Discharging Loads. (5 *Figs.*) October 10, 1917.—Means or arrangements for hoisting and discharging loads, specially, though not exclusively, adapted for use in the charging of blast furnaces, comprise an inclined runway 1, on which is mounted a counterbalanced skip carriage or traveller 2, traversed up and down by a rope drive, the ropes of which, connected at one of their ends with the skip carriage, are first carried up the runway, then pass over head pulleys 5, then pass down the runway to the winch 7, from which they pass, under tension pulleys 8, to the skip carriage to which their other ends are connected. The skip carriage has, in accordance with this invention, two drums, or sets of drums 9, 10, arranged in parallel, geared together so that they rotate in the same directions and has the ropes of the rope drive connected to the drums in such manner that as rope is wound on to one of the drums, or set of drums, it is unwound from the other drum, or set of drums. The skip 20 is connected with the gearing and is raised and lowered and also discharged thereby. For this purpose, one wheel 15 of the gearing has drums attached to its sides to which chains 18, which carry the lid 19 of the skip, are attached in such manner that, when fully paid out, their points of attachment with the drums are at the lower ends of vertical



diametral lines. It thus follows that if, when the chains are fully paid out, the chain drums be rotated in either direction, the chains are wound thereon and the skip is raised. The lid of the skip has depending hooks 24 into which a cross-head 25, from which the bottom of the skip is suspended, fits. The hooks and the parts of the crosshead that engage therewith are made so as to prevent the skip from swaying when being traversed. The skip in its traversing position has its lid held rigidly against stops on the skip carriage. (*Accepted October* 23, 1918.)

MINING, METALLURGY AND METAL WORKING.

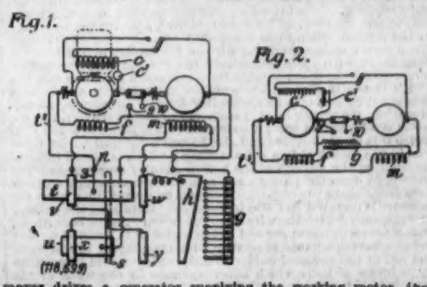
120,114. Wellman, Seaver and Head, Limited, London, and F. G. Smith, Purley. Steel-making Furnaces or Mixers. (2 *Figs.*) November 12, 1917.—This invention has for its object to provide steel-making furnaces, or mixers, in which a part of the structure is used to afford communication between portions, such as between the furnace port and the port of the regenerator, with a sealing device. According to this invention, the trough A of the seal which surrounds the lower



port X contains a second sealing device B holding liquid, into which enters a projection C surrounding the upper port Y, the said second sealing device being provided with means *d*, *e*, which will cause it to rise, or to be raised, in the liquid in the trough A when the seal is made, the second sealing device B descending, or being lowered, in the trough A to break the seal around the upper port, and rising or being raised, in the liquid to re-make the seal. (*Accepted November* 6, 1918.)

MOTOR ROAD VEHICLES.

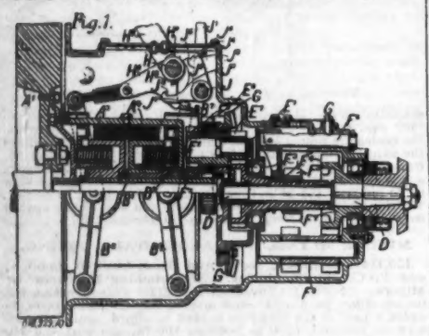
118,699. W. A. Stevens, Maidstone, and Joseph Sankey and Sons, Limited, Bilston. Motor Road Vehicles. (6 *Figs.*) September 24, 1917.—In electric transmission systems for motor vehicles, cranes, rolling mills, &c., in which a prime



mover drives a generator supplying the working motor, the generator is designed for supplying at times a lighting, arc-welding, or like load by being compound-wound, the generator series field *f* being used as a shunt to the motor series field *m* when

the motor is driving in the forward direction. With the motor at work, a variable resistance g consisting of sections in parallel is placed in series with the generator series field and the generator shunt field e and variable resistances e^1 are placed across the motor armature. The reversing controller consists of four cross-connected fixed contacts v, w, x, y, and two segments t, u, on a spindle s, the segment t being connected by the flexible leads to the controller terminal n connected to one of the generating brushes. As shown in Fig. 1, the controller is in the forward-drive position. When a lighting or other load is to be supplied, the shunt field is placed across the generator armature by a separate two-way switch, and the controller is put in neutral position; the motor field is then short-circuited, the motor armature disconnected by the segment u, and the variable resistance g is placed in shunt to the generator field; the supply is taken from the terminals 9, 10. In the reverse-drive position, the generator series field is shunted by the segment t and conductor t^1 of comparatively low resistance, some current still flowing through the field f. The movable contact h of the resistance g may, in addition to a hand control, be moved by the brake pedal on a vehicle or a separate pedal corresponding to the clutch pedal; this pedal may be interlocked with the change-speed lever, so that the latter cannot be moved until the generator series field is broken. (*Accepted September* 18, 1918.)

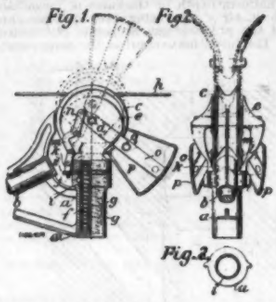
118,929. G. von Zweigbergk, St. Annes-on-Sea. Change-Speed Gears. (8 *Figs.*) October 19, 1917.—In epicyclic variable-speed gearing, the governing member of the gear is geared to a compound-wound dynamo-electric machine which acts as a yielding reaction-device. Clutches A^3, A^4, are provided for connecting the driving flywheel A1 to sleeves B1, B2, which carry gear wheels F6, F1, gearing with compound planet wheels E^5, E^2, turning in a carrier E1. Integral with the wheels E^2, E^5, are wheels E7, gearing with a wheel F^5, on a sleeve F^4, which carries a sliding wheel F^6, having three positions corresponding to a reverse drive of the shaft D through gearing F^6, F7, a neutral position, and a solid forward drive. The planet carrier E^1 carries a gear wheel G driving the armature G^5 of a dynamo-electric machine represented in Fig. 2. The machine is compound-wound and has a series winding G^4, and a shunt winding G^6, connected across a battery G^6. A switch L controls the flow of current. The clutches A^2, A^4, are engaged by spring action and are normally disengaged by levers B^5, B7, controlled by a plate H^4, on a shaft H, rotated by a pedal lever H^2, and by a locking plate J^3, on a shaft J, rotated by a hand lever J1. When engaging any speed, the lever H^2 is first lowered to the position



shown, disengaging both clutches. The lever J1 is then rocked about an axis at right angles to the shaft J and through levers and links shifts a notched rod F^6, which moves the wheel F^5, into position for forward or reverse speed. The lever J1 is then rotated to engage one of the notches J^4, J^4, J^5, on the plate J^2, with a spring catch J^6. Lugs J^7, J^4, J^5, on the locking plate J^2, are arranged to co-operate with the lever B^7, and stops H^5, H^2, on the plate H^4, respectively. When the lever H^2 is released, it returns by spring action and the plate H^4 is arranged to release the lever B before the lever B, the adjustment of the locking plate J^2 ensuring that either the clutch A^3 or the clutch A^4, or both together, are engaged. When only one clutch is engaged, the switch L is in the position shown in full lines in Fig. 2 so that the planet carrier is rotated backwards against the resistance produced by the shunt and series windings acting together, and the shaft D is slowly started. When both clutches are engaged, the gearing rotates solid in the forward direction and the plate J^2 is adjusted to allow the lever H^2 to return to the top of its stroke when it moves the switch L to the dotted line position, and the shunt and series windings oppose each other and reduce the electrical resistance to motion. With the parts in this position the electrical machine may be used to start the engine. (*Sealed.*)

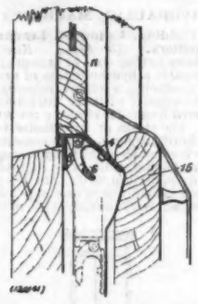
RAILWAYS AND TRAMWAYS.

120,187. W. Pickersgill, Lockwood, Huddersfield, J. H. Pitt, Crosland Moor, Huddersfield, and F. Haigh, Thornton Lodge, Huddersfield. Trolley Heads. (5 *Figs.* July 18, 1918.—This invention relates primarily to trolley heads for electric traction, which are provided with wire-finding means of the type in which forks are moved up and down according to the pressure of the overhead wire on the trolley pulley by their connection with spring-supported journal boxes of the pulley. a represents the boom bracket having a boom b secured thereto, and c is the trolley pulley which is mounted on a spindle d journalled in bearings in the trolley head e. According to this invention, the trolley head is secured to a hollow shank f, and the latter is adapted to enter a socket a^1 in the boom bracket a, in which it is free to revolve and also to move vertically. Confined within the socket a^1 is a spiral spring g which is placed in compression by the descent of the hollow shank f under pressure of the wire A upon the pulley c and acts to force same upwardly or outwardly again to the position shown by dotted lines when the pressure is removed and also to assist in maintaining the pulley c in engagement with the wire A under normal running conditions. Into a recess in the upper end of the socket a^1 is inserted a short sleeve i having a flange i^1 thereon which is adapted to rest upon the end of the socketed holder, the sleeve being held in position by a series of balls which enter openings in the walls of the socketed holder and engage with the shank to form ball bearings therefor, outward displacement of the balls being prevented by the shank. The head e can thus freely rotate to any extent desired independently of the boom bracket which is also free to swivel about the shank f. To the flange i^1 is appropriately secured a bracket k having upstanding ends to each of which are pivotally connected links l pivotally connected by a cranked link m to links n pivotally connected to a short arm extending from a lever o pivotally mounted on the spindle d. To each side lever o is secured a wire finder p whose outer end is curved outwardly to enable it to embrace and conduct the overhead wire to a position in alignment with the centre of the groove in the pulley c. Stop-pieces on the holder a serve to limit the circular movement of the trolley pulley and parts to approximately half a revolution, the stud which secures the bracket k to the flange i^1 projecting below the flange and being adapted to contact with



the lugs at the predetermined extents of motion. The wire finders p have a roll or stud q extending between them, with which the overhead wire first engages when applying the pulley to the conductor, the guide forks being then in their upright position and the trolley head in its highest position. When the guide forks are in this position, the centres through the links and levers o are in alignment. Pressure of the wire on the roll q and then finally on the trolley pulley causes the descent of the wire finders to inoperative position, the descent of the trolley head and pulley being effected by the pressure of the wire on the trolley pulley against the action of the spring g whose expansion on removal of the pressure will reinstate the parts in their highest position again in readiness for the finding and re-engaging the conductor with the trolley pulley. (*Accepted November* 6, 1918.)

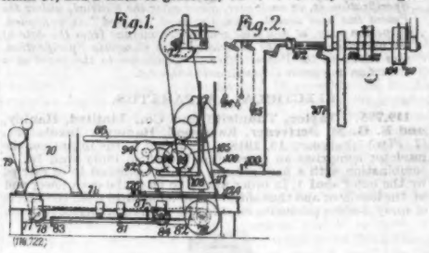
120,141. J. G. Robinson, Fairfield, Manchester, and Industrial Appliances, Limited, Westminster, London. Railway Carriage Drop Lights. (7 *Figs.*) December 17, 1917.—This invention relates to improvements in draught excluders for the drop lights of railway carriages. The invention consists of a draught excluder comprising a flap 4 hinged underneath the drop light or window frame 11, and having associated

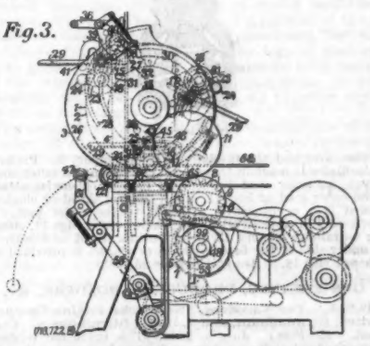


with it a lever, or levers, 6 which co-operates with a fixed cam 5 attached to the light rail, so that when the window is closed the cam operates to lift into and lock the flap in its operative or draught-excluding position with its lower edge engaged in a recess in the garnish rail 15, and when the window is lifted and lowered in the usual way the cam becomes inoperative and the flap adopts a vertical depending position and offers no obstruction to the lowering of the window. (*Accepted November* 6, 1918.)

TEXTILE MACHINERY.

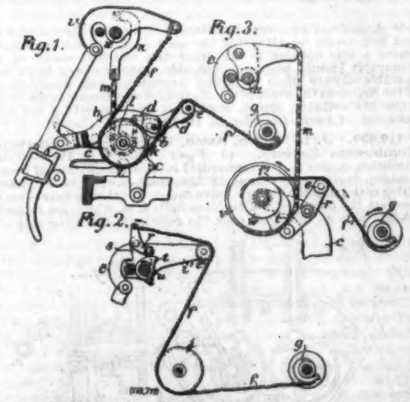
118,722. J. and T. M. Greeves, Limited, Belfast, J. V. Eves, Belfast, and J. Foster, Belfast. Spinning. (8 *Figs.*) October 20, 1917.—The sticks of flax are spread by an operative upon one or more smooth plates or pans which are held in a stationary position for the purpose, and intermittingly moved forward to deposit the sticks upon the feed-lattice of the spread-board. In the form shown in Fig. 3, three plates 29 are carried by discs 1, 2, journalled in brackets 3, and rotated intermittingly by a segment wheel 5, spur wheel 6 and gearing 9, 11, 13. A Geneva stop device 7, 8, locks the wheel 6 for a fraction of its revolution. The plates 29 are attached to bars 15, 16, 17, having trunnions 18 projecting through bearings on the disc 2 and carrying arms 23 with rollers 24, 25, in different planes and adapted to contact with cams 26, 27, 28, respectively. These cams are carried by the brackets 3. At the outer end, the bars have trunnions projecting through bearings in the disc 1 and carrying loose wheels 31 gearing with a stationary wheel 32. The wheels 31 are clutched to the trunnions against the action of a spring by a cam 30. The combined action of the rollers 24, 25, bearing on the cams 26, 27, 28, and of the gears 31 which intermittingly rotate the bars 15, 16, 17, is to cause the plates 29 to occupy an horizontal position whilst the discs 1, 2, are stationary, to maintain them in such position for rather more than one-third of a revolution, then to cause them to take up a vertical position, and finally to turn them right over and deposit the flax upon the feed-lattice 66 of the spread-board. The flax is held upon the plates 29 by grippers 39, 40, connected together by gears 45, 46. The grippers 39 carry arms 43 with runners 38 and arms 42 with runners 41. The revolution of the discs 1, 2, carries the runners 38 against a lever 37 and opens the grippers, allowing the operative to lay the flax upon the plate 29. By moving a handle 36, the lever 37 is caused to release the runner 38 and to allow the grippers to fall upon the flax. They are raised again to allow the deposition of the flax upon the feed-lattice 66 by the engagement of the runner 41 with a cam 65. The flax is laid upon the lattice by the plate 29 moving forward from under it. The end hanging down in front of the lattice is held thereon by a roller 47 carried by arms 58, 61, controlled by cams 48, 53. The arms 61 are pivoted to the arms 58, and the roller 47 is pressed against the feed-lattice by springs 63. The roller 121 of the feed-lattice is carried on journals on a cross-stay connecting the brackets 3, 4, and the lattice can be tightened by adjusting the gables 117 carrying the brackets 3, 4, on a slide 124, Fig. 1, by screws 126. The speed of the mechanism for laying the flax upon the spread-board lattice may be varied to give as long a dwell as possible to allow the operative to place the flax upon the plates and to make the depositing and the returning movements of the plates as fast as possible. The surface speed of the lattice and of the spread-board rollers are kept in unison with the speeds of the laying mechanism. The laying mechanism and the spread-board 70, Fig. 1, are mounted upon a platform 71 and are driven from the overhead shaft 72. The spread-board is driven by cone pulleys 76, 77, and a chain 79. The position of the belt on the pulleys can be adjusted by a screw 81 moving the belt forks 82, 83. The laying mechanism is driven from a cone pulley 78 on the same shaft as the pulley 77, by a second pulley 84, a chain 87, and a train of gears 92, 94 . . . 98, the last gear





being on the shaft 99 carrying the segment gear 5. The speed of the laying mechanism is varied by adjusting the belt on the cone pulleys and by the change pinion 92. The shaft 72 is driven through one or other of the fast pulleys 101 or 110, Fig. 2. When the flax is spread upon the plate, the operative depresses the treadle 100 to drive the shaft at a quick speed. The second belt is then on the loose pulley 104. To change to low speed, the cam 105 depresses the lever 106 and operates through the rod 107 to place one belt on the loose pulley 111 and the other on the fast pulley 110. The belt forks are carried by slides controlled by a pin 102 on a slide carrying one fork working in a slot in a slide carrying the second fork. To stop or start the machine, handles 114, 115, control the movements of the slides. The plates upon which the flax is spread may be carried by a cam-operated pendulum member or by a sliding member carried by rails and moved by a cam lever, and link. In these cases the plates merely oscillate and no turning-over mechanism is required. (*Sealed.*)

118,711. J. Pickford, Oldham. Self-acting Mules and Twiners. (10 *Figs.*) October 5, 1917.—In a backing-off chain motion, the chain is kept tight at the commencement of a set of cops and is lengthened or slackened as the winding-faller moves downwards. The winding-faller is slowed down when nearing the thread coils at the bottom of the spindle. The backing-off chain f, Fig. 1, is attached to a snail g on the tin roller shaft and passes over a pulley c carried by a lever d on the end of the link b connecting the fish jaw lever c to the boot-leg and also over a pulley i, on a stud k carried on the fish-jaw lever



A second chain m is adjustably attached to a link s on the faller i, and passes round a pulley l on the stud k to the end of the lever d. The pulley c may be carried on an arm at the end of the link b, or the lever d may be mounted loosely on the stud on the fish-jaw lever that carries the pulley i. The chain f, Fig. 2, may pass from the snail g round a pulley i and a pulley d^2 on the faller sector i, to a lever r carried by a bracket s. The other end of the lever r bears on a cam t on faller shaft u. If two pulleys v, w, Fig. 3, are used with chains s, f^1, the cam t may be secured to one of the pulleys and act on the lever r, which carries a pulley s over which the chain f^1 runs. (*Sealed.*)